AGRICULTURAL ENGINEERING

JUNE • 1953

In this Issue . . .

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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AGRICULTURAL ENGINEERING

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Vol. 34, No. 6

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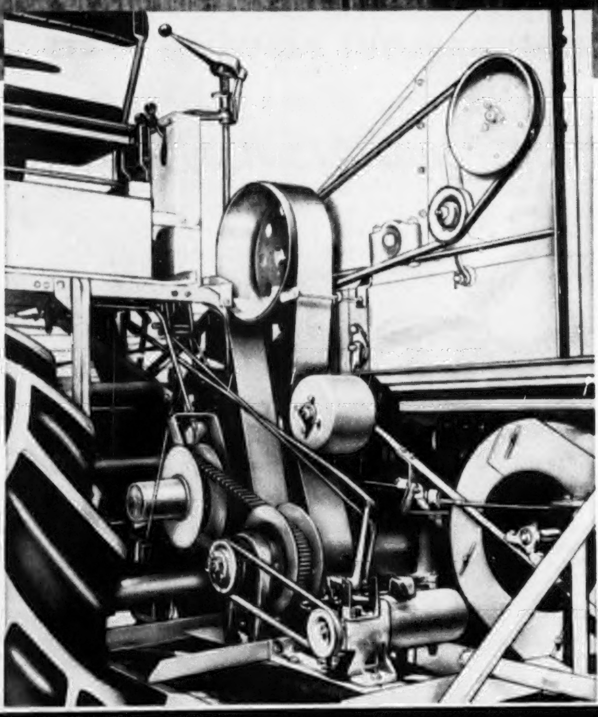

This is a close-up of the conveniently located variable speed drive on the new Massey-Harris 90 SP combine. The Dayton Double Cog-Belt transmits power from the main drive jackshaft to the transmission gear case. The foot-operated variable speed control is hydraulically-controlled, actuating the speed change mechanism without regard to engine speed.

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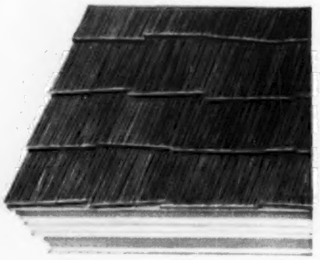

Each shingle is designed as a rigid asbestos-cement strip, covers as much area as 5 individual shingles. American Colonials are self-aligning, nail holes are prepunched. Application is simple and rapid.

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D-17

Invents rotary hoe to improve cultivation

E. F. Pitre (right) of New Iberia, Louisiana, the inventor, explains operation of the vertical-vaned hoe to John Curtis, prominent farmer. The hoe makes possible close cultivation without injuring the roots, according to Mr. Pitre.

Mr. Pitre gives bearing a shot of Marfak lubricant. Marfak ensures full lubrication protection – forms a collar around the bearing edges, sealing out grit and dirt. Marfak sticks better, stays on longer, won't melt down and run out or dry out. The implement is Mr. Pitre's horizontal rotary hoe. Texaco Man Floyd Folks is an interested observer.

USING the basic principle of the hand hoe, Mr. E. F. Pitre, of New Iberia, Louisiana, has developed two types of rotary hoes–vertical and horizontal, as shown above.

Some of the advantages claimed are closer cultivation, with adjustable depth of cultivation. Thus it is possible to cultivate a crop as soon as the plants begin to appear, breaking up the crust and speeding plant growth.

Mr. Pitre and the Curtis brothers, like farmers the country over, have found that *it pays to farm with Texaco Products.*

In all 48 states Havoline, the motor oil with a reputation of more than 40 years behind it, is the choice of leading farmers. Havoline is a Heavy Duty all-purpose oil, ideal for gasoline or Diesel engines and those using LP-Gas as fuel. It cleans as it lubricates, ensuring full power and economy from every drop of fuel. Pete Van Zee near Lynden, Wash., is pouring the Havoline as friendly Texaco Man E. A. Hofman looks on.

Friendly service with on-time deliveries, that's what farmers and ranchers want and get from Texaco Men. In addition, they get better performance, longer trouble-free life from farm machinery with Texaco Products. Texaco Man D. S. Spidle is delivering a tankful of Fire-Chief, the gasoline with extra *"Fire-Power"* for low-cost operation, at the Sandifer farm near Beaumont, Texas.

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Texaco Petroleum Products are Manufactured and Distributed in Canada by McColl-Frontenac Oil Company Limited.

Making fertile acres from untamed land

Near Bay City, Texas, is a stretch of virgin land, choked with giant oaks, pecans and underbrush. So dense is the foliage, that sunlight cannot penetrate deeper than 10 or 15 feet. Limbs and trunks are so tightly entangled they form a barrier through which even a goat cannot pass. For centuries this jungle-like area has grown wild. There was just no way to clear it profitably.

But with the introduction of bigger, more powerful postwar tractors, the picture has changed. Today, giant Allis-Chalmers torque converter tractors are wading right through it — ripping out brush, up rooting trees, clearing more in one hour than a crew of hardened men could hack out in a month. Best of all, they are laying bare some of the most fertile soil ever to be found west of the Mississippi River delta.

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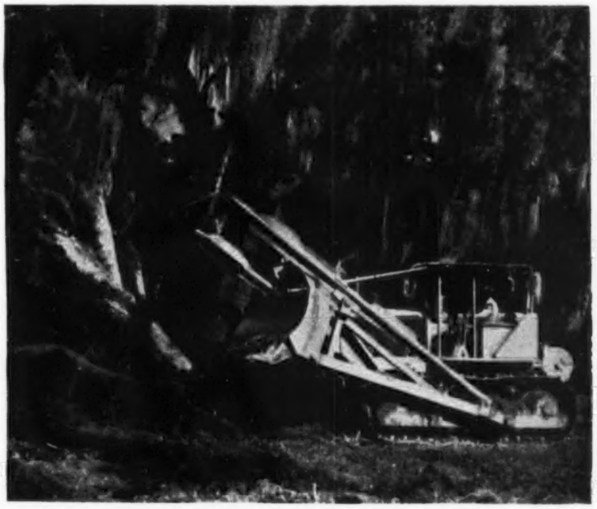

COMING UP—BY THE ROOTS When the big Allis-Chalmers Tractor and dozer applies its weight and power against a tree, the tree gives way! Special "tree knocker" bites into the trunk 14 feet above the ground exerting leverage which even the biggest in the area cannot resist.

WINDROWING After trees and brush are ripped up, the tractors push them into long rows. Piles will remain here until they are dry enough for burning.

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ALLIS-CHALMERS

TRACTOR DIVISION · MILWAUKEE 1, U. S. A.

AGRICULTURAL ENGINEERING

VOL. 34 JUNE, 1953 No. 6

Electronic Detection and Removal of Tramp Iron from Chopped Hay

John B. Dobie, Frederic C. Jacob, and Leroy C. Kleist
MEMBER ASAE ASSOC. MEMBER ASAE

AN EXPERIMENTAL tramp-iron remover has been built which can remove 99 percent of the wire and nails from pneumatically conveyed chopped hay. The iron is rejected along with about one pound of hay when an electrical signal from a detector coil operates a solenoid-controlled door in the conveyor pipe. The tested model works with hay and air speeds up to 6,000 fpm, but there is nothing in the setup to prevent operation at greater speeds. The device is intended for use with silage as well as hay.

The prevalence of tramp iron in hay and feed causes significant losses to dairymen every year. Hardware sickness, or traumatic gastritis, is the result of some foreign object, usually a piece of iron, penetrating the wall of the stomach (Fig. 1). Because of their feeding and digestive habits, cattle are particularly susceptible to this disorder. At one time nails were the most common cause. In 1926, Bosshart* reported that of 24 cases 18 were caused by nails, two by wire, one by a hairpin, and three by both nails and wire. The smallest article was a shingle nail, the longest a 4-in piece of baling wire. Dr. Christensen and associates in the University of California college of veterinary medicine clinic indicate that 1 to 6-in pieces of baling wire now cause about 90 percent of their cases of traumatic gastritis. A 2-in piece is most dangerous. Fig. 2 shows a collection of wire removed from a cow. All pieces shown had pierced the wall of the reticulum. A similar collection was found loose in the reticulum and rumen. Nearly all tramp metal found in the stomachs of cows has been ferromagnetic.

The growing incidence of baling wire in hay and grass silage is a result of the increase in field baling and chopping. Careless operation of wire-tie field balers may result in short ends or whole bale ties being deposited in the bales or left in the field to be picked up in a subsequent cutting. Chopping hay from contaminated fields or chopping baled hay are common ways of introducing bite-size wire into the cow's ration.

Incidence of hardware sickness varies with locality, but the problem exists wherever hay is fed to cows. In areas where twine-tie balers are used exclusively or where no baling is done, tramp iron still finds its way into the feed as pieces of fence wire, nails, staples, broken machinery parts, or pieces from haywired machinery. Barnyard manure spread onto hay land may be contaminated with tramp iron.

The most serious problem in removing tramp iron from feeds arises with stemmy materials such as hay and silage. Plate magnets, magnetic pulleys, duct magnets, and the air-flotation process may all be used to advantage for removal of iron from liquid, ground, or granular feeds. In the case of hay and silage, however, the duct magnet alone has gained a common place in farm installations, but only with partial success.

A duct magnet, which is a short section of blower pipe

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Rural Electric Division.

The authors — JOHN B. DOBIE, FREDERIC C. JACOB, and LEROY C. KLEIST — are, respectively, associate specialist in agricultural engineering, assistant specialist in agricultural engineering, and former junior specialist in agricultural engineering, University of California (Davis).

*J. K. Bosshart, case report by Cornell Veterinarian, vol. 16, no. 4, 1926.

Author's Note: The authors are indebted to J. B. Powers, University of California (Davis) for his contributions to this investigation and to the California Committee on Relation of Electricity to Agriculture, under whose auspices this project has been conducted.

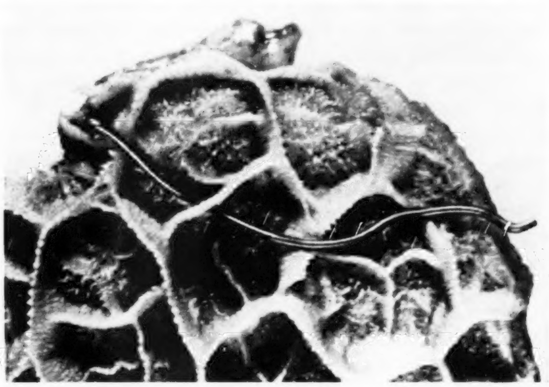


Fig. 1 Section of a cow's reticulum showing embedded wire. Further penetration would be likely, and would normally cause infection or even death to the animal

Fig. 2 Wire and nail removed from one cow by veterinarian's operation. Paper match at upper right is for size comparison

with two or more plate magnets placed as baffles, may be used in a pneumatic system to remove tramp iron from the hay. Reasonable efficiency may be expected provided the hay is dry and is not conveyed at too high velocity. Basing his figures on several years' experience, one manufacturer of magnetic ducts† estimates the following efficiencies in iron removal:

Center-throw chopper-blower............75 to 95 per cent
Chopper with attached external blower 70 to 85 per cent
Tangential-outlet chopper-blower.....20 to 50 per cent

These figures show that the tangential-outlet blower, a type commonly used on farms, cannot be properly protected against tramp iron with a duct magnet. Duct magnets are often used on top-outlet chopper-blowers, but tramp iron continues to slip by and cause losses in cattle.

Another approach to the problem is to remove some of the hay at the same time the iron is removed. A commercially available metal detector was sought which could be made to operate a rejecting device to kick out the iron and the hay surrounding it. Several manufacturers produce metal detectors that operate at maximum conveyor speeds of about 600 fpm. In conjunction with a belt conveyor such a detector could suffice, but a pneumatic conveyor may operate at more than ten times this speed.

EXPERIMENTAL DETECTOR

The experimental iron detector is one especially intended for high conveyor speeds. It is not sensitive to moisture or non-ferrous metals, since its search field is steady—similar to that produced by a permanent magnet—rather than alternating, as usually used for metal detectors. A ferromagnetic material passing through the weak magnetic field causes a momentary disturbance in that field because of a change in reluctance of the magnetic path. This changing flux linking with the pickup winding generates a small voltage in that winding, which is then fed to the detector amplifier. The lines of flux in the pipe are axial. If other than ferromagnetic materials were to be detected, then a transverse field might by employed, since a flux change would be caused by eddy-current losses.

A fast-moving piece of iron produces a greater rate of change in the field and induces a higher voltage in the pickup winding than a slow-moving piece. Thus advantage is taken of the fact that iron pieces in hay handled pneumatically are travelling fast.

To apply this or any detection system to pneumatically conveyed chopped hay, the signal generated in the pickup winding must be amplified and made to operate a rejection device placed downstream from the inspection coil (Fig. 3). Timing of these operations must be accurately controlled because the iron-contaminated hay is moving at a rate of 100 to 160 fps through the blower pipe. It is essential that the electrical circuit be completed and the rejection device operated as quickly as possible to minimize the distance the iron travels before being rejected. Hay and iron travelling 160 fps would allow only 0.1 sec for the iron to move 16 ft in the pipe. In most installations the blower pipe enters the barn 20 to 25 ft from the ground. Allowing for the height of the blower outlet, this leaves 15 to 20 ft of vertical rise in the blower pipe before it enters the barn. At this maximum blowing velocity, then, if the iron is to be rejected before entering the barn, the rejection device should operate in 0.15 sec or less.

†Letter from Columbia Engineering Service Co., San Francisco, Jan. 28, 1952.

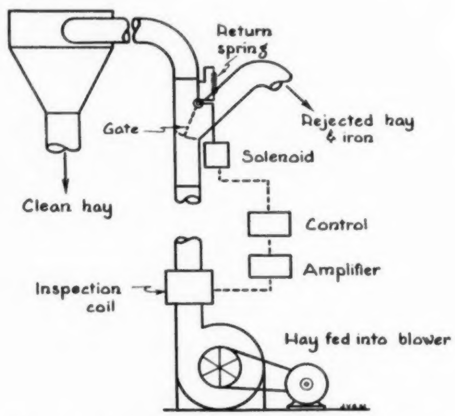


Fig. 3 Sketch of detector-rejector system. Tramp iron passing inspection coil generates a small voltage that is amplified and energizes gate solenoid. The minimum distance from coil to gate is determined by air speed and by speed of gate movement

In planning a suitable rejection device to operate on a pneumatic chopped-hay conveyor, several criteria must be satisfied. It must operate quickly and easily to meet the time factor. It must be positive in action, requiring a close fit to insure that all the hay and iron are rejected when the device is in the reject position. It must not impede the normal flow of hay and air, and must be self-cleaning when operated. Nothing can be used that might occasionally tend to clog the blower pipe. It must be built ruggedly to carry the weight of pipe attached to it and still maintain its close fit and ease of operation.

Thus a system to remove tramp iron satisfactorily from chopped hay by this method involves three interrelated pieces of equipment, each a separate engineering problem.

THE INSPECTION FIELD

As implied earlier, the inspection field consists of a means to produce a steady magnetic field and a winding to detect changes in that field. The magnetic field is weak, in the range of 100 to 150 gauss, since it would be objectionable to have a magnetic field strong enough to catch and hold pieces of iron at this point. The pickup winding is located within the magnetic field, where it will be affected by disturbances produced by passing pieces of iron. Because of its non-magnetic properties, a short section of aluminum blower pipe is used for mounting the inspection-field assembly. Motion of the pickup winding with respect to the field will also generate a voltage which cannot be distinguished from the voltage produced by iron. It is necessary therefore to provide rigid construction of the inspection assembly. In addition to vibration, metal detectors may be somewhat sensitive, when operated from a power-line source, to disturbances caused by other electrical equipment. The effect of spurious signals resulting from these conditions can be minimized in equipment design. Increasing the sensitivity of the detector, however, increases the difficulty in eliminating the unwanted signals and increases the cost of the device. Veterinarians generally agree that pieces of iron shorter than ¾ in are not likely to cause hardware sickness. With this information as a guide, the design of the electronic detector was aimed at a sensitivity sufficient to detect reliably a piece of baling wire ½ in long.

THE AMPLIFIER-CONTROLLER

Sensitivity of the system is dependent not only on the strength of the signal provided by the inspection-field pickup coil, but also to a lesser extent on the design of the amplifier. The signal can be amplified to any reasonable amount. Amplification of 500 times by a conventional voltage amplifier with pass band centered at about 200 cycles per second increases the output of the pickup coil to several volts. This is sufficient to operate a thyratron (high-speed electronic switch).

Operation of the reject device is controlled with the thyratron and two relays. A high-speed relay is used for actual operation of the gate, resulting in a total operating time for all electrical parts exclusive of the reject gate of less than 10 milliseconds. This allows most of the operating time of the system to be available for operating the reject gate. Such a high-speed relay has operated satisfactorily under test for an estimated 300,000 times, probably more than would be required in several years' operation in a farm installation. The thyratron-relay unit performs two additional functions.

It must provide a specified hold time on the reject gate in its reject position. This is because variation in operating speed of the blower, friction on the blower pipe, or overloading may cause the piece of tramp iron to move more slowly than its anticipated maximum speed. The coil-to-gate distance must be established by the maximum velocity of the iron. Any reduction from this velocity must be compensated for by holding the gate in reject position until the piece has been ejected positively. In order that the loss of hay may be kept at a minimum the hold time should also be kept at a minimum. Present experiments range up to 1 sec hold time, with an average of ½ sec.

The relay circuits take care of the possibility of a second piece of tramp iron passing the inspection coil before the first piece has been rejected and the gate returned to normal. A long piece of wire entering a chopper would be cut into short pieces following each other in rapid succession. If the gate was required to return to normal position before rejecting a second piece of iron, such a rapid-fire condition would result in some iron escaping rejection. The hold-time circuit therefore provides that a new rejection cycle can be initiated at any time, regardless of the position of the reject gate. Should the door be in the reject position at the time a second piece of iron is detected, it will be kept in that position for another normal hold period. Should the reject door be in its return stroke when an impulse is received, it would immediately be re-energized to return to the reject position.

In the experimental amplifier-controller an additional relay switch is incorporated to operate a buzzer in the event of a tube failure. An external light indicates power continuity.

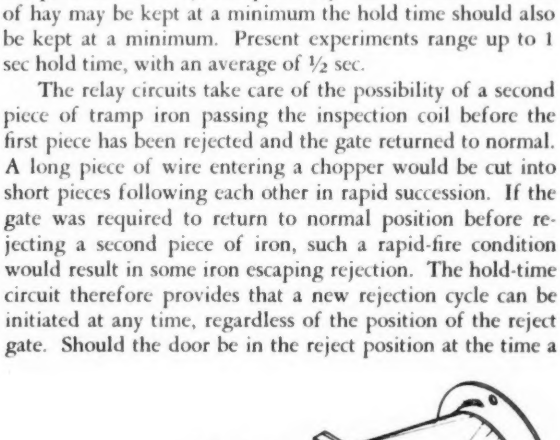


Fig. 4 Cutaway drawing of experimental gate in reject position

THE REJECT GATE

The single-vane gate, as shown in Fig. 4, is a sturdily constructed version of the simple deflector gate often used in pneumatic systems. In its normal position, the vane forms one side of the duct, with hay and air passing straight through. In moving to the reject position, the vane swings across the duct, leaving an opening through which the iron, hay, and air are deflected. As one path is closed, another is opened. When the change takes place, hay may momentarily flow in both paths. Careful construction permits a close fit, with little possibility of hay or iron jamming the vane.

Gate Design. The design of the vane is of utmost importance because of its high operating speed and the resultant large amount of kinetic energy which it must absorb during acceleration. If there is no force from air or hay on the gate vane, or if the torque from the source is balanced out by construction, then the equation of motion of the vane is

$$I\,(d^2\theta/dt^2)+S\,\theta=T-S\,\theta_0 \quad [1]$$

where I = inertia of the system
θ = angle vane makes with its normal position
S = torsional constant of return spring
t = time
T = solenoid torque
θ_0 = angle of preset in return spring.

Movement from the normal to reject position, denoted by the subscript 1, is represented by the solution of equation [1]

$$\theta_1=(T-S\,\theta_0/S)\,[1-\cos\sqrt{(S/I)}t] \quad [2]$$

Similarly, movement from the reject to normal position is denoted by the subscript 2

$$\theta_2=(\theta_b+\theta_0)\cos\sqrt{(S/I)}t-\theta_0 \quad [3]$$

where θ_b is the maximum angle made by the vane to its normal position.

The maximum bending moment occurs at the start of a stroke. At the beginning of the normal-to-reject stroke this moment is

$$M_1=I_v(T-S\,\theta_0)/I+X_a \quad [4]$$

and for the reject-to-normal stroke

$$M_2=-I_v\,S/I\,(\theta_b+\theta_0)+X_b \quad [5]$$

where I_v = inertia of the vane only
X_a = air and hay torque for vane in normal position
X_b = air and hay torque for vane in reject position.

Equations [2] and [3] yield the times τ_1 and τ_2 for the gate to open and close.

$$\tau_1=\sqrt{(I/S)}\cos^{-1}[1-S\,\theta_b/(T-S\,\theta_0)] \quad [6]$$

$$\tau_2=\sqrt{(I/S)}\cos^{-1}[\theta_0/(\theta_b+\theta_0)] \quad [7]$$

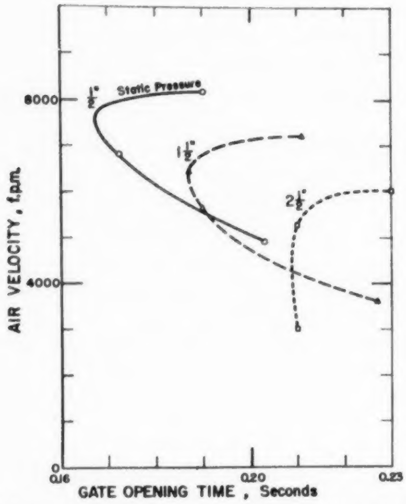


Fig. 5 Relation of static pressure, air velocity, and operating time of 8-in gate for one experimental arrangement. Vane is of 16-gage iron, double construction

Inertia of the vane and solenoid plunger is

$$I = (\rho\, b\, d^4/3 \sin^3\theta_b) + (m\, y^2/\theta_b^2) \quad . \quad . \quad . \quad . \quad [8]$$

where ρ = density of vane
b = vane thickness
d = blower pipe diameter
m = mass of solenoid plunger
y = solenoid stroke.

This equation shows that as the size of the gate is increased to accommodate increased pipe diameter the term representing vane inertia varies with the fourth power of the diameter increase. The second term representing the solenoid has been found to be small. Equation [6] shows that the operating time will change as the square root of inertia, hence as the square of pipe diameter. If the vane thickness is increased, then the effect of inertia may be even greater in limiting operating speed.

The preceding equation of motion assumed the torques caused by air and hay movement to be cancelled out. The gate shown in Fig. 4 does not cancel these effects. The torque X_a caused by air static pressure p for this gate design is

$$X_a = p\, d^3/2 \sin^2\theta_b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [9]$$

This torque, increasing as it does with the cube of blower pipe diameter, imposes a practical restriction on the size of such a gate. The solenoid must be large enough not only to overcome this torque but must stretch the return spring and still have reserve for accelerating the vane.

Means for cancelling the forces caused by pressure and velocity heads are desirable. A balanced (butterfly valve) construction would be satisfactory but would increase inertia. A mechanical arrangement of springs could be employed on a simple vane, but would become less effective as the required range of operating conditions was increased.

Gate Construction and Data. To facilitate construction, the gate is made in square cross section of 1/4-in steel plate. (The 8-in gate is constructed of 3/8-in aluminum plate.) The reject pipe is at a 45-deg angle from the downstream side. All joints are made with machine screws to forestall the possibility of warping from application of heat in welding.

A single thickness vane of 16-gage iron operated in the

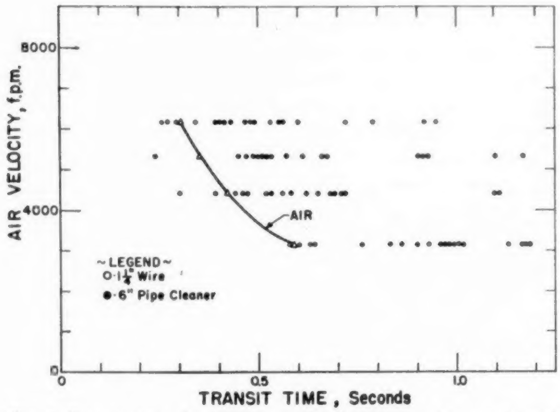


Fig. 6 Transit time of wire pieces and tobacco pipe cleaners through 31 ft of 8-in blower pipe

6-in gate with 36-in-lb of torque failed after several hundred operations in an air stream averaging 4,500 fpm velocity. A double thickness of 16-gage iron assembled as shown in Fig. 4 withstood 200 to 300 thousand operations with the same force applied but with a somewhat higher average air velocity. Tests on a similar vane of 26-gage spring steel in the 8-in gate operated 1000 times with 55 in-lb of torque and 7000 fpm air velocity without indication of failure. The lighter material resulted in faster operation.

Power for moving the vane is supplied by a solenoid because it is quick acting and easily controlled electrically. Satisfactory results have been attained on the 6-in and 8-in gates at velocities up to 6000 fpm with solenoids providing 18 lb and 27.5 lb pull, respectively. All tests have been made with 1½-in solenoid stroke through a 2-in lever arm.

A soft return spring (½ to 1 lb per in elongation) is desirable for fastest operation of the gate, but its use is limited to a maximum air speed of about 4,500 fpm on the 6-in gate. A stiff spring (16 lb per in) was found to be more satisfactory for high-velocity operation. At low static pressure, some preset in the spring is necessary to hold the vane in its normal position. With high static pressure, the preset is not needed, thus reducing the spring load on the solenoid during the initial part of its stroke. On the return stroke a force due to velocity pressure must be overcome in addition to that of static pressure.

The effect of air velocity on the experimental 8-in gate for a given installation is shown in Fig. 5. At a given static pressure gate-operating time decreases with increasing air speed up to a critical point, beyond which a reverse effect is obtained.

Observations of Farm Forage Blowers. The wide range of velocities of air and hay in the blower systems complicates the problem. Designing a single-vane gate for operation at high velocity means overdesigning for the average condition. Manufacturers' recommended operating speeds on their blowers indicate a considerably lower air velocity than has been found in numerous actual installations.

Table 1 shows data taken on three installations, which are representative of what has been found in the field.

TABLE 1. FIELD OBSERVATIONS ON BLOWER SPEEDS

Type of blower	Maker's recommended rpm	Observed rpm	Maximum velocity of air in pipe, fpm
Tangential outlet blower	700	1,040	8,490
Ensilage mill w/attached blower	2,050	2,260	9,390
Top outlet hammermill	1,750	1,876	6,340

From these figures it appears that chopper blowers are normally operated more nearly at manufacturers' recommended speeds than forage blowers. Capacity of the chopper is the controlling factor. In the case of the forage blower, the capacity is mainly a function of its speed. If the pipe tends to plug, the operator increases the speed of the blower until it will handle forage at the rate he wishes to feed it. One commercial operator was operating his blower at such speed as to obtain nearly 11,000 fpm air speed at the end of the pipe. Field tests indicate that, to handle most field conditions, the reject gate should be made to operate throughout an air-speed range of 6,000 to 10,000 fpm.

Static pressure varies with the amount of pipe, the number of bends or restrictions, and the velocity or amount of air blown. A cyclone increases static pressure materially. Static pressure in the system may range above 6 in of water.

COIL-TO-GATE DISTANCE

Speed of operation of the reject gate has been of principal concern. The faster the gate can be operated, the nearer it can be placed to the inspection coil. For gaging this coil-to-gate distance, tests were performed to determine the speed of iron particles travelling through the blower pipe. Two detector coils were used, separated by 31 ft of pipe, and the time between signals of the two coils was measured. These data, shown in Fig. 6, permit estimates of necessary operating time and hold time for any chosen coil-to-gate distance.

The tests were made without hay. There was a wide variation in the time of transit of the wire, as could be expected. A few wires traveled faster than the maximum air speed because of the throwing action of the fan blades.‡ Many were slower because of friction on the sides of the pipe. When wire was mixed with hay, this variation could be expected to be greatly reduced, more like the range of the tobacco pipe cleaners. There was relatively little variation in the time of transit of the pipe cleaners, since they were airborne (as would be the case with hay). The curve shows the maximum velocity of the air through the blower pipe.

The location of the reject gate will be determined by many factors in any given installation. The coil-to-gate distance will be a limiting factor, but in most cases it will be desirable that the reject gate be placed in the wall of the barn or inside the barn. Because of the weight of the unit, it should be located where it can be supported easily and will seldom have to be moved. Provisions must be made for collecting the rejected material.

‡G. Segler: Calculation and Design of Cutterhead and Silo Blower. AGRICULTURAL ENGINEERING, vol. 32, pg. 661, December, 1951.

EXPERIMENTAL RESULTS

In the laboratory it has been demonstrated that a metal remover as described above can be made to eliminate 99 percent of the potentially dangerous iron pieces in hay. When adjustment was optimum, 400 consecutive metal pieces were passed through the pneumatic system and all 400 were removed. Under one field situation (Fig. 7) with the same equipment, 34 pieces of miscellaneous nails and wire were removed from about three tons of hay that had been condemned because it had caused much hardware sickness. The smallest piece was a shingle nail, the largest a coiled bale wire. A second run of the hay through the iron remover produced no rejections, and it was believed all the iron had been removed on the first run. Subsequent feeding of the hay produced no more trouble.

In a second field test the equipment was exposed to rain and fog and operated for a day every 10 days over a two-month period. An estimated 65 tons of hay were processed, and about 230 pieces of wire, nails, and miscellaneous iron pieces were removed, ranging from ½ to 12 in long. Fig. 8 shows 108 pieces removed from 25 tons of this chopped hay.

Both field trials were made using a 6-in-diameter blower-pipe system. A unit for 8-in pipe is in the laboratory stage, but has not been field tested.

SUMMARY

Tramp iron in chopped hay is an important factor contributing to hardware sickness in dairy and beef cattle. Successful laboratory trials and limited field experience indicate that dangerous tramp iron can be removed from chopped hay, and probably from silage, by a rejector which removes some hay with the iron and which is controlled from an iron detector. Sensitivity can be made ample to detect all pieces of iron of a size dangerous to cows. A test model of the device operates over a considerable range of the operational variables encountered in actual installations pneumatically conveying chopped hay. The equipment is not unduly complicated, and it is felt that economically such a metal remover is feasible.

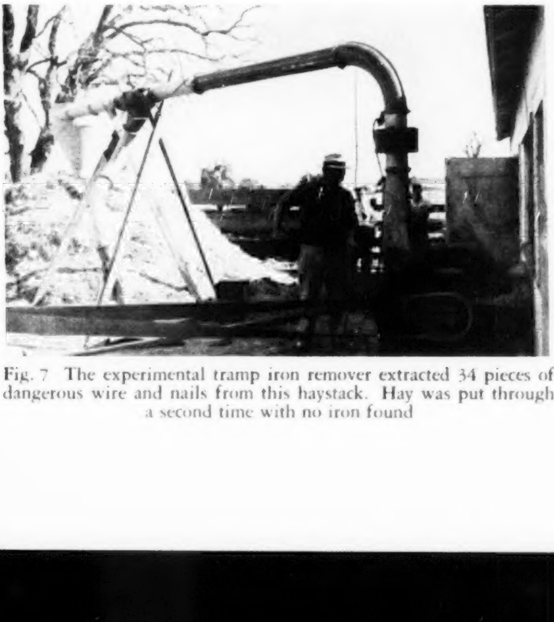


Fig. 7 The experimental tramp iron remover extracted 34 pieces of dangerous wire and nails from this haystack. Hay was put through a second time with no iron found

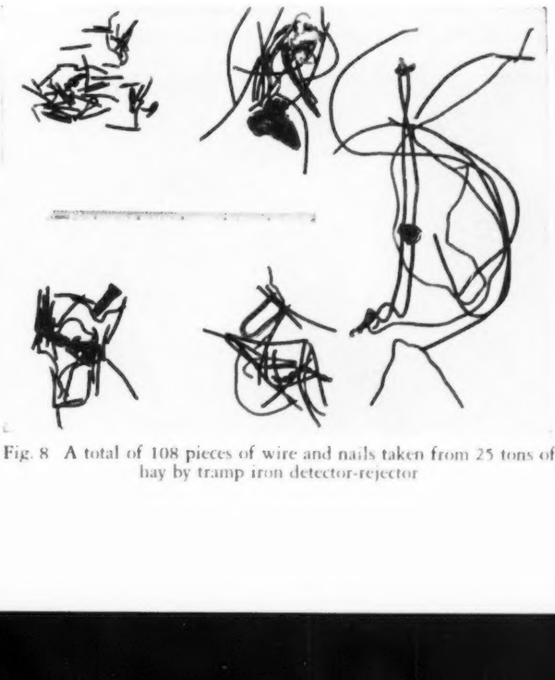


Fig. 8 A total of 108 pieces of wire and nails taken from 25 tons of hay by tramp iron detector-rejector

Power and Torque Distribution in Farm Machine Drive Shafts

D. E. Burrough
ASSOC. MEMBER ASAE

THE need for a method of measuring power and torque distribution in various drive shafts of farm machines is well recognized by farm equipment manufacturers. Such measurements coupled with a detailed knowledge of the characteristics of such loads will be a valuable aid in the improvement of existing machines and in the development of new ones.

Methods for determining the total power consumption of a machine such as a combine, baler, etc., have been used; however, the adaptation of these methods to the component drives of a machine is almost an impossibility. In the cases where these methods have been extended to the measurement of the load distribution, extensive changes in the machine were necessary.

The purpose of this paper is to show how the desired load characteristics may be obtained under field-operating conditions. The method requires only minor changes in the machine, thereby reducing the cost of the instrumentation and assuring that the machine being tested will have the same characteristics as production models of the same design. The initial equipment cost is approximately $2500 and the cost per shaft including labor is $30.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1951, as a contribution of the Power and Machinery Division.

The author—D. E. BURROUGH—is assistant professor of agricultural engineering, Purdue University.

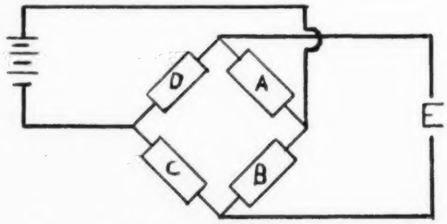


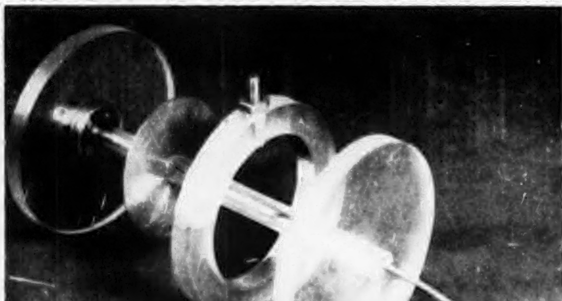
Fig. 1 Electrical circuit for torque measurement

Application of Wire-Resistance Strain Gages: When a round shaft is subjected to a pure torisonal load, theoretical analysis shows that the principal strains occur on planes, the angles of which are 45 and 135 deg to the direction of the applied load. A strain gage placed on the shaft along a 45-deg helix will be subjected to a strain either compressive or tensile dependent upon the direction of the load.

Since the relationship between the induced strain and the applied load is linear up to the elastic limit and also the change in resistance of the gage is linear with respect to the induced strain, the change in resistance of the strain gage is a direct relationship with the applied torque.

Practically all shafts transmitting power are subjected to a transverse load. This type of loading induces a strain on the surface of the shaft which must be cancelled if the signal from the gages is to represent only the torsional load. Four active gages are used to eliminate the effect of the transverse load and also to provide a greater signal representing the applied torque. The gages are connected to form a Wheatstone bridge (Fig. 1). The two gages lying on the same helix and displaced radially by 180 deg form opposite legs of the bridge. By this placement the gages in the opposite legs of the bridge sense the same magnitude of strain due to bending but of an opposite sense, and consequently the bridge remains in balance.

In most cases single gages may be used to construct the bridge; however, the grids of the gages are displaced by approximately ½ in along the shaft. This condition means that all g ges do not sense the same magnitude of strain due to bending. On some installations where the ratio of bending moment to torsional moment is high, this effect shows as a cyclic change in the record level. The effect due to bending can be cancelled entirely by the use of a strain gage rosette, since this type of fabrication makes it possible to locate the active portion of the gages at the same position along the shaft. Since the rosettes are rather stiff, they are not adapted to application on a shaft whose diameter is



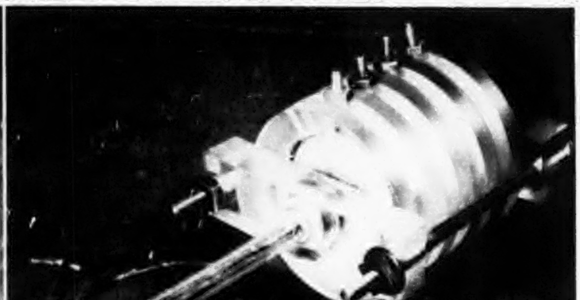


Fig. 2 *(Left)* Exploded view of one collector cell • Fig. 3 *(Right)* Assembled view of a collector

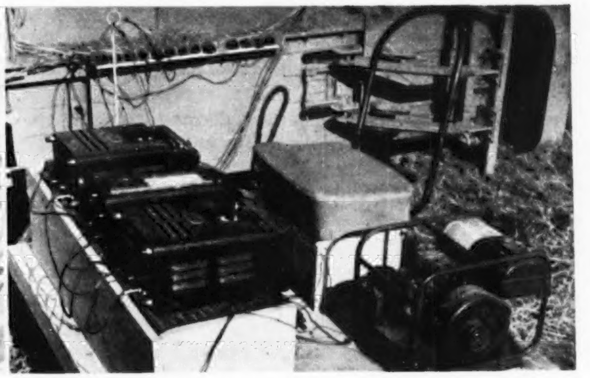


Fig. 4 *(Left)* Collector installation • Fig. 5 *(Right)* Recording equipment and generator

less than 1 in. Usually the effect due to bending is not noticeable and the use of single gages makes it possible to locate the bridge on the shaft, if there is available an axial length of one inch.

Transition Unit From Rotating to Stationary Circuit. In measuring torsional strains on rotating shafts a collector must be used to make contact between the strain-gage bridge and the recording units.

The most common method used is the slip-ring and brush collector. The slip-rings rotate with the shaft and the brush contactors are stationary. This type of collector is satisfactory for some installations; however, the lower limit for accurate results is around 6000 psi in torsion. In many cases the induced stress due to torsion is below this figure making it necessary to increase the stress level in the region where the gages are located.

The common procedure to increase the stress level has been to reduce the cross section of the shaft. This method is applicable if the shaft is not subjected to a combined loading; however, in practically all cases the drives of an implement are powered by belts, chains or gears, all of which produce bending in the shaft. Once the cross section has been reduced for the purpose of increasing the torsional stress level, the shaft is not able to carry the additional transverse load. This condition makes additional support bearings necessary which in turn increases the cost of the instrumentation. Commercial torque-meters may be used but in most cases the use of this item requires support bearings and a jackshaft to transmit the power. These changes, while costly, also disrupt the normal power train, thereby changing the characteristics of the drive.

A mercury-bath collector was developed in an effort to obtain the desired characteristics of stable contact resistance and equal resistance under static and dynamic conditions.

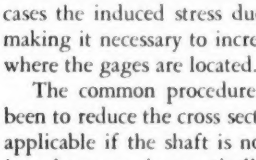
The collector was made with four cells to accommodate the four lead wires from the bridge. Contact was made through a rotating disk and a stationary ring which were in contact with a mercury well. Plastic was used to make the non-conducting portion of the cell with copper disks and rings for the conducting elements. Figs. 2 and 3 show an exploded view of one cell and an assembled collector respectively. The over-all length is 4 in and the width is 3 ⅛ in. The rings and disks were amalgamated with mercury to give more stable resistance characteristics. Laboratory tests were conducted to determine the variation in resistance of the cells.

The resistance varied from 0.00585 ohms at static conditions to 0.00565 ohms at 2500 rpm. The voltage variation across a resistor in series with the collector was not noticeable on an oscilloscope with a preamplifier even during the transition period when the mercury was changing its position from a well at the bottom of the cell to a ring around the inside of the cell.

Tests conducted under actual operating conditions indicate the lower limit of the collector is approximately 350-psi torsional stress with a recorded deflection of 1 in. A torsional load of only 60 lb-in would induce this stress in a shaft 1 in in diameter. With this stability the lower limits of the torque-measuring technique is no longer governed by problems involving the transition from rotating to stationary elements of the circuit.

Tests conducted to date on various agricultural machines indicate an average induced torsional stress of around 2000 psi. As can be seen, this method will give readable records under these conditions.

Installation of the Gages and Collector. The collector is driven by a rubber connection between the shaft to be measured and the collector rotor. This type of connection allows some angularity and axis displacement between the shafts.



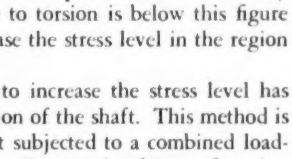


Fig. 6 *(Left)* Loading characteristics of a combine fan drive shaft • Fig. 7 *(Right)* Starting torque requirements of a flywheel-type forage harvester

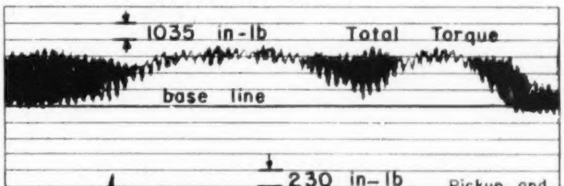


Fig. 8 Torque requirements of the feeder and pickup drive and the main drive on a forage harvester

The strain gages are applied directly to the shaft to be studied. A clearance of approximately 1 in is necessary along the axis of the shaft while a radial clearance of 1/8 in is sufficient. Lead wires are connected to the four corners of the bridge and brought out to the collector. The usual precautions must be followed in preventing shorts to ground and between lead wires. The gage installation is then covered with plastic insulating tape for protection which is sufficient for approximately a four-month period.

If the gages are installed inboard of the bearing, the shaft must be rifle-drilled to provide a passageway for the lead wires. When it is possible to place the gages outboard of the bearing, it is not necessary to rifle-drill the shaft. Fig. 4 shows the collector installed on a combine for measuring the power required by the separating mechanism.

COLOR CODING ESSENTIAL FOR MAKING CONNECTIONS

A color coding should be followed and adhered to in all cases to aid in making the wiring connections and tracing difficulties that might occur.

The connections between the collector lead wires and those from the gages are made by bringing each to the outside of the rubber coupling. Brass bolts are used to secure the lead wires together. After the connection is made, each lead wire is wrapped with insulating tape. To facilitate removal, one part of the rubber connector is fixed to the shaft being tested and the other half to the collector rotor. A rotating connection is made by a small plastic plug which slips into the two pieces of rubber tubing. This arrangement makes it possible to remove the collectors from the machine being tested and yet retain relatively easy installation for tests in other crops.

In the tests conducted to date the torque in only two shafts have been recorded simultaneously. Two Brush model 310 strain analyzers connected to a two-channel Brush direct-inking oscillograph have been used to record the data. At present the power supply, amplifier and recording equipment can be mounted on a space approximately 3 ft square (Fig. 5). If the equipment cannot be mounted on the machine, a small instrument cart supported by a caster wheel can be attached to the machine being tested.

The power for the unit is supplied by a small 60-cycle, 110-v generator. Since this unit is well shielded, 60-cycle pickup has been negligible even at the highest amplification. This is particularly true when the recording equipment has been grounded to the generator frame.

Test Procedure. Mechanical calibration was used in all cases, since careful application of the calibrating load provides a direct reading on the record. This eliminated many errors possible with electrical calibration. At the end of each test, the unit was recalibrated to check for a change in the sensitivity of the strain-gage bridge or accidental misadjustment of the amplifier.

In some cases the strain-gage bridge must be placed very close to the bearings. Due to the heat generated by the bearings, drift in the zero torque level on the record is sometimes evident since the gages are very sensitive to temperature gradients. In all cases this drift can be eliminated by operating the machine up to speed until the shaft has reached equilibrium conditions, and then completing the test run. When it was possible to locate the gages three inches from the bearing, there was no evidence of drift. After each run, the machine was allowed to stop completely to determine if there was a shift in the zero torque base line during the run.

The shaft speed in most cases can be obtained from a characteristic cycling of the load. However, this cycling was used only as a check against the event marker record and the tachometer readings. The event marker received an impulse each time the shaft completed a revolution. By counting the number of revolutions indicated for a given length of chart the revolutions per minute were determined since the chart speed was known.

The average torque was determined by obtaining the area in a selected length of chart with a planimeter and dividing this area by the length. This average height was multiplied by the calibration factor to determine the mean torque. The horsepower requirements could then be determined by the relationship, $hp = 2\pi NI/33{,}000$.

Three or more test areas were selected on the chart for each run and the horsepower for the particular test condition was taken as the average determined from the selected areas.

Analysis of the Loading. Although the primary intent of this paper is to show the technique of obtaining the measurements, the type of records and resulting analysis show the value of this method.

The records obtained show the variation in torque caused by the different units linked by gears, belts or chains with the drive being studied. This factor allows the investigator to determine the actual conditions under which the drive operates.

RECORDS SHOW VARIATION IN TORQUE BY DIFFERENT UNITS

The maximum and minimum applied torques and the frequency of the cycling is immediately evident from the record. As noted during one test, the characteristic loading of a fan had a torque range of approximately 400 lb-in, but the addition of a unit which acted as a flywheel reduced the range to 200 lb-in. The primary cause of this variation could be traced back to a reciprocating unit in the same drive. Fig 6 shows a representative portion of the loading for the fan drive shaft.

During tests of a forage chopper the piston impulses from a four-cylinder engine caused a torque range of 3000 lb-in under partially loaded conditions. These impulses had a frequency of 60 cycles per second since the engine was running at 1800 rpm. The starting torque required for the flywheel cutter is shown in Fig. 7. The total torque requirement and the requirements of the pickup feed rolls and conveyor drive are shown in Fig. 8. The power required for the chopping and blowing process can be obtained by subtracting that required by the header units from the total power required.

Limitations and Benefits. Although the test setup is simple, its use must be limited to a small group of engineers who understand the functions and characteristics of the machine being studied. These men should be familiar with the strain-gage method but need not be trained in all phases of the strain-gage technique.

The same group who conducted the field tests should supervise if not do the analysis of the resulting data. This is necessary since certain characteristics will be evident on the resulting record which can be best analyzed by those men who conducted the tests. *(Continued on page 386)*

Liquid Meter for Slow and Varying Flow Rates

J. H. Pomroy and C. K. Otis
MEMBER ASAE

FOR measuring the quantity and rate of flow of juice flowing from an experimental soil filled with high-moisture hay silage, a means of measuring and recording was needed. Such a device had to work in a damp atmosphere, and had to be self-operated and dependable over a long period of time. It had to be capable of recording the total juice flow and also the rate of flow which varies considerably. It was necessary also that it be easily cleaned and have few moving parts.

Using a suggested method of volume measurement, a meter was developed that satisfied the above requirements and in addition operated over extended periods with little or no attention. The device described consists of the following parts:

1 The revolving drum within which the metering is done
2 A welded steel pipe frame
3 A retarding device that prevents the drum from discharging liquid before the metering compartment is filled
4 A mechanical counter for recording the drum revolutions
5 A microswitch that actuates a solenoid-operated marking pen on a time chart.

The heart of the device is the revolving drum. Within the drum there are four compartments (Fig. 1). The inlet compartment is of cylindrical shape concentric with the hollow shaft located on the central axis of the drum. In the sides of this compartment there are three slots forming the inlets into three metering compartments symmetrically placed around the central compartment. Each of the three metering compartments is identical. Each has an inlet slot, a dam, an air vent, and a discharge duct. The dam confines the initial flow of the incoming liquid at the inlet end of the metering compartment causing the drum to quickly come to rest after discharge of liquid from the previous compartment. The air vent insures complete filling of the compartment. A discharge duct at the periphery of the drum empties the metering compartment as the drum revolves.

The drum is made from galvanized sheet metal coated on the interior with an asphaltic paint and on the exterior by a rust-resistant paint. Although a transparent plastic front is not necessary, it was found to be extremely valuable for observing the operation of the device, since the liquid within could be seen, making it easy to check the proper filling of the metering compartments.

Two sealed precision ball bearings were mounted in standard pipe floor flanges which were bolted to the ends of the drum concentric with its central axis. The bolt heads on the front face of the flange are used as lugs for the retarding device (Fig. 2). A special head formed on one of the bolts on the rear flange actuates the mechanical counter and the microswitch (Fig. 3). The hollow shaft on which the bearings rotate is cantilevered from the frame. A slot along the bottom of this shaft forms the inlet for the liquid entering the drum.

The flow of the liquid from the silo is directed into the hollow shaft and discharges into the cylindrical compartment of the drum. As the liquid rises in this compartment, it flows through a slot into one of the three metering compartments surrounding the cylindrical section. Flow continues, filling the metering compartment completely and then filling the cylindrical section to the level of the

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The authors — J. H. POMROY and C. K. OTIS — are, respectively, instructor and professor of agricultural engineering at the University of Minnesota.

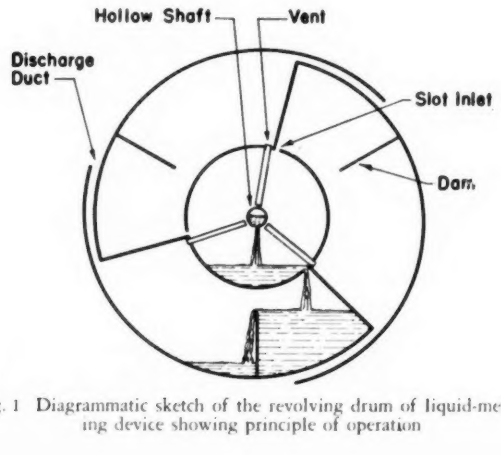


Fig. 1 Diagrammatic sketch of the revolving drum of liquid-metering device showing principle of operation

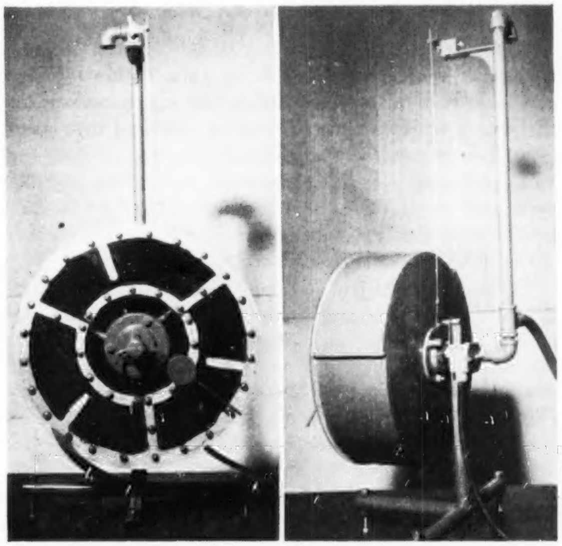


Fig. 2 (*Left*) Front view of liquid meter. Metering compartments can be seen through plastic face. Retarding device is shown in foreground. Mechanical counter and air vent at top • Fig. 3 (*Right*) Rear view of liquid meter showing hose inlet connection, microswitch for electrical recording of drum revolutions, bell-crank linkage for mechanical revolution counter and metering compartment outlet at periphery of drum

slot inlet to the adjacent metering compartment. From this point on any additional liquid will flow into the adjacent compartment effectively unbalancing the drum and causing it to rotate. A slight rotation of the drum isolates the filled compartment and any additional unbalancing causes the drum to rotate further, lowering the elevation of the discharge lip thereby allowing the compartment to empty itself. The drum has then revolved one-third revolution and is in position for tne filling of the second metering compartment. This process is repeated continuously until the flow of liquid to the meter ceases.

By calibration, the volume of liquid discharged in one revolution of the drum can be determined. The drum revolutions are recorded on the mechanical counter through a linkage attached to the frame. The same lug on the drum that actuates the mechanical counter also operates a microswitch which in turn causes a solenoid-operated marking pen to make a mark on the edge of a time chart, furnishing data that can be used in calculating the rate of flow at any time. Power failure will temporarily knock out the marking pen, but the mechanical counter continues to record the total number of revolutions of the drum.

The frame consists of a three-legged base with leveling screws and an upright column to which is welded the hollow drum shaft. Attached vertically to the back end of the shaft is a vent pipe which also acts as a support for the mechanical counter. A pipe tee at the base of the vent pipe serves as the liquid inlet to the hollow shaft. Supports for the microswitch and mechanical linkage are welded to the hollow shaft. A standard ratchet-type counter is used to record the total number of revolutions of the drum. The lug on the drum flange actuates a bell crank which in turn operates the ratchet counter through a linkage. The counter is mounted high on the vent pipe since the device is used in a pit and this high mounting permits easy reading of the counter.

MICROSWITCH MEASURES THE RATE OF FLOW

For measuring rate of flow, a fully enclosed microswitch, in response to the action of the lug, completes the circuit to a solenoid-actuated marking pen on a time chart. In the case of this installation the marking pen was mounted on a thermocouple recorder that was recording temperatures in the silo. A mark is made at the edge of the chart for each revolution of the drum, and from this data and the capacity of the drum, the rate of flow can be determined.

Although a change in design may possibly eliminate the need for a retarding device, it was found necessary in this case. A lever arm hinged at one end to a collar fastened to the front end of the hollow drum shaft is held down by a counterweight secured to the arm by a setscrew (Fig. 2.) A projection on the arm strikes one of the bolt heads protruding from the front flange of the drum preventing rotation until the metering compartment is completely filled. The weight of the liquid flowing into the next compartment forces the drum to turn against the retarding effect of the counterweight. The projection on the arm slips by the bolt head, the arm drops again to the down position and the next bolt head comes to rest against the projection. The collar on which the fulcrum bearing is mounted is adjustable on the hollow shaft and the position of the counterweight on the arm can be changed. With

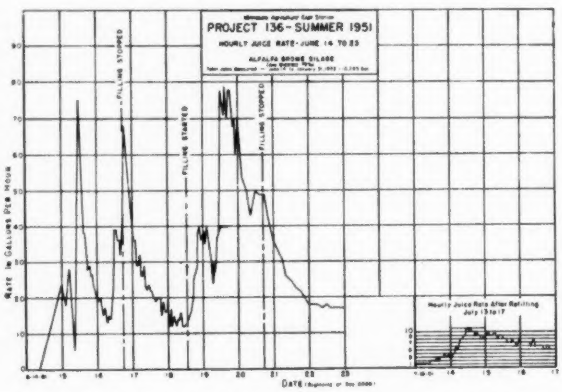


Fig. 4 Hydrograph of juice flow from an experimental silo (14x45) filled with legume silage having average moisture content of 79 per cent

these adjustments the correct positioning of the drum to assure complete filling of the metering compartment can be obtained.

This device can be used for very low flows of liquid up to a probable maximum of 250 gph. Since very little liquid is exposed to direct contact with the air, very little loss by evaporation can take place, even though it takes several hours to fill one of the compartments.

Calibration of this meter with water as the liquid gave the following results:

Rate of flow, gph	Discharge of drum, gal. per revolution
14.3	5.51
47.1	5.54
180.0	5.58

Extrapolating these data it was found that for rates of flow between 0 and 100 ghp, which was the range required for measuring silage juice, the maximum probable error, assuming 5.50 gal per revolution, was 1.2 per cent. In the full range from 0 to 250 gph maximum, probable error would be 1.8 per cent.

A partial hydrograph of juice flow from an experimental silo is shown in Fig. 4. Maximum flow rate was approximately 78 gph and the total quantity of juice exceeded 10,000 gal.

Power and Torque Distribution

(Continued from page 384)

The load requirements of the machine can be determined under varying conditions thereby making possible the accumulation of data that will be useful reference for future and current designs.

SUMMARY

1 The cost of equipment and materials for this type of testing is approximately $2500.

2 The cost of instrumentation is $30 per shaft which includes the labor cost.

3 The test setup is simple and adaptable to a field-testing program.

4 The actual testing should be limited to a small group of engineers who are familiar with the method but need not be trained in all phases of strain-gage technique.

5 By the use of this technique, the existing loads can be determined for future reference.

Why Cultural Education for the Engineer?

Russell R. Raney
MEMBER ASAE

MY REMARKS are directed primarily to that group of young men who are just now completing their formal technical educations and to another group of young men who have, in the past five years, completed their formal educations and are now in the process of finding a home in the industrial community. I would appreciate, however, having my own contemporaries listen carefully with the thought in mind of being able to modify or supplement my observations in the discussion which I hope will ensue at the conclusion of my remarks.

During the course of your formal schooling, I know that you were all showered with a great deal of advice on the particular subjects which you ought to take in order to become a successful engineer. This well-intended counsel invariably included not only specific suggestions as to technical topics, but also some less specific but equally emphatic suggestions of cultural or technical topics outside the engineering fields, such as economics, accounting, sociology, history, political science, psychology, or anthropology. And, while the relationship between the technical engineering studies and the successful performance as an engineer has been fairly obvious, the connection between the non-technical courses and the practice of engineering has not been nearly so evident. The chief object of my remarks, then, will be to establish a clearer relationship between the comprehensive curriculum and the realities of engineering practice.

The situation of the trained engineer with respect to industry is similar to the situation of the trained lawyer with respect to the field of politics. Successful passage of the bar examination may indicate an acceptable knowledge of the mechanics of government, but this does not automatically qualify a person for holding public office, even though such knowledge is thought to be a highly desirable attribute. We have to recognize the fact that just as there are many successful public office holders who are innocent of any legal training, so there are also many successful persons in positions of industrial responsibility who have not had the benefit of a technical education. It is evident that these persons possess certain skills which are thought to outweigh any technical deficiencies, so it should be instructive to examine the kind of tools and techniques they employ in finding solutions to the problems of industry or government.

The techniques of management may be illustrated by selecting a group of commonly encountered problems and observing the manner of finding solutions. Because of your particular interest, I have selected five problems involving engineers, but it should not be thought from this that engineers are responsible for all of the difficulties in the industrial firm. The given conditions of the problems are relatively simple: a selling organization marketing a line of products, a manufacturing organization operating certain plant facilities, a design engineering department whose members possess certain technical and inventive skills, and an executive organization which relates the activities of the three groups to each other and to the economic and governmental world about them. Now I should like to point out that these internal organizations are quite similar to factions in a political party in that while they all strive toward the same end, they do not necessarily agree among themselves as to the means to be employed in achieving that end. So it is to be expected that the normal operation of the business will be marked by a certain amount of internal conflict as each organization seeks to promote its own particular interest. These areas of conflict give rise to the problems which I shall now introduce.

The first problem arises at the time the development program is born. Such programs may be prompted either by the sales department or by the design engineering department and must, of course, have executive approval before work actually begins. But when we stop to consider the contrasting interests of the sales and design groups, it is easy to see that a complete agreement at this point may not be reached without executive pressure being brought to bear. Sales-minded persons tend to recommend the development of machines which resemble those being marketed by successful rival firms—partly because the competitive models are known to be in good demand and partly because a program of imitation takes a minimum of time to execute. The design engineering department, on the other hand, tends to propose the development of machines which are, at the very least, improvements over the competitor's design, or, in many instances, machines which are totally new by comparison to the offerings of the current market. Although the end result is usually more desirable, the development time required is always much greater and less ponderable because of the unknown factors which may be involved. These viewpoints may be summed up by saying that the sales department takes a short-run view while the design engineering department takes the long-run view. Before we yield to our natural bias as engineers and exponents of progress (whatever that is) and condemn the sales department for its shortsightedness, let us bear in mind that the money is made in the short run, and in the long run we are all dead. Problem number one, then, is one in which engineers are vitally concerned, but there is no convenient handbook formula we can turn to in finding a rational solution.

One of the consequences of this situation is the tendency, in many large firms, to establish a research department or long-range-view department which is beyond the control or advice of any member of the sales department. The research department is not called upon to put out fires but is expected to serve as insurance against what the future may bring.

Let us assume that somehow—probably by executive counsel—a program has actually been launched and carried through to completion. Problem number two arises in connection with the transition from experimental models built by hand in the design engineering department to production

This is an address delivered before a meeting of the Iowa-Illinois Section of the American Society of Agricultural Engineers at East Moline, Ill., April 29, 1953.

The author—RUSSELL R. RANEY—is supervisor of engineering, farm implement division, International Harvester Co.

models built in quantity by the manufacturing department. Tooling up for mass production is a complex process, and it is not surprising that the parts fabricated with the aid of elaborate dies, jigs, fixtures, and automatic machine tools do not resemble precisely the handmade parts of the prototype models. As a matter of fact, it is frequently impractical and occasionally impossible to produce satisfactory replicas, in quantity, of the parts as originally designed. Consequently, the turnover of the finished design to the manufacturing group is always marked by a large volume of last-minute revisions made to accommodate the manufacturing processes.

Design engineering personnel naturally have a good appreciation of manufacturing technique. Any obvious failure to take good shop practice into account will always be challenged by the tool-design group anyway, so it should be clearly understood that the real difficulties arise after the tooling program has been completed and when pressure is being brought to bear for the fabrication of completed machines. It is the actual experience with the finished tools which brings the variances to light, and while many of them are easily reconciled by a simple drawing change, there are usually a few which cannot be handled so readily. An impasse is typically reached in those situations where the design engineering group takes the position that to accept a change would jeopardize the ability of the machine to perform satisfactorily, and the manufacturing group takes the position that to develop the tools actually needed would require additional capital and time to get the job done. When we take into account the fact that the sales department is standing impatiently by, having now waited two or three years for the public unveiling of the new model, it is easy to see that the executive arm will again make itself felt in pressing for an early resolution of the problem.

DESIGN IMPROVEMENTS POSSIBLE DURING TOOLING

The third problem usually arises simultaneously with problem two and may be thought of as an inversion of the second situation. Because tooling programs usually require some appreciable length of time for their execution, the design engineering department is frequently able to make improvements over the design on which the tooling program was originally predicated. But to insist on last-minute design changes means pulling the rug out from under the position of the manufacturing department which has made commitments to suppliers of materials, and has scheduled the fabrication of parts in its plant—and that schedule, it must be remembered, must usually be fitted in with the schedules of numerous other machines. On top of this, there is always some commitment to the executive organization. On the other hand, neither the sales organization nor the executive organization ever wishes to be in the position of seeming to close the door on possible improvements so that executive umpiring of these disputes always looks like a desire on their part to have their cake and eat it too.

Let us again assume that somehow the critical birth pangs of the new machine have been endured and that smoothly flowing quantity production has actually been achieved.

Inevitably there comes the time when the sales department begins to encounter resistance in certain territories because of the lack of special features required by local conditions. The field of farm machinery furnishes numerous examples of this situation because of the variation in agricultural practices found in different parts of the country. Now the typical response of the sales department is to request as many variations in machine construction as are required to meet the entire range of agricultural practices. Carried to an extreme this is nothing less than a demand for custom-built machinery, so problem number four becomes evident in trying to determine how far we are going to go in filling the requests for special constructions. It is usually easy enough to design these variations, but to ask the manufacturing group to supply these features or attachments—usually in small quantities—means to ask for frequent interruptions of the production process. These interruptions naturally impair the manufacturing efficiency; hence, its is no surprise to learn that, if the plant is operating at or near capacity output, the resistance to making additional special features or attachments will be tremendous. On the other hand, the absence of one variation in one machine may interfere seriously with the sale of other company products in a particular neighborhood.

DIRECTING TECHNICAL ACTVITIES TO SHOW PROFIT

The fifth and last problem is, of course, that of so coordinating and directing this group of technical activities as to show a profit from the complete operation. In this area, sales, manufacturing and design engineering are all at odds with the executive group, for the sales department wants low selling prices to make the goods easier to market, the design engineering group tends to overdesign the product to insure certainty of operation, while the manufacturing group tends to make frequent purchases of new equipment and to stockpile materials in order to maintain uninterrupted plant operation. Now it happens that the executive arm of the firm is also interested in low selling prices, quality design, and continuous plant operation but not to the extent of running the business into bankruptcy. Consequently, the management's simultaneous desire to set prices which are certain to return a profit, to limit the quality of the design, and to keep a tight rein on equipment expenditures and inventories lends a Dr. Jekyll and Mr. Hyde aspect to every managerial act and makes every problem solution a compromise with respect to the interests involved.

We have now sketched a picture of the industrial firm in which certain internal organizations, separately responsible for the design, manufacture and sale of a line of product, come into conflict with one another as a normal part of doing business. There are two comments I would like to make with respect to this situation.

First, these conflicts are a healthy thing for the firm as a whole because they constitute a check-and-balance system similar to the legislative, executive and judicial arms of the federal government. If any one of the internal organizations of the industrial firm succeeds in having its own selfish way in every encounter, then the firm will suffer from an unbalanced perspective on every new problem with which it is faced. So it is not only desirable but completely necessary for the sake of the firm to have all sides of a given situation adequately presented in order to arrive at a balanced judgment.

Secondly, I want to make it clear that these conflicts do not arise from capricious human behavior. Errors of judgment, greed, ambition, jealousy and the lust for power do enter into and confound and confuse every situation, but the

human relations problems are additional difficulties over and above the inherent and irreducible minimum of conflicts. They would still be present even if the industrial firm was manned by a staff of saints.

The industrial firm is a cultural phenomenon peculiar to a society which is dominated by competitive economic activity. Its presence in the community distinguishes our society from every other past or contemporary society, but it is not the product of unbridled human nature.

The executive has been depicted as an arbitrator of inherent internal conflict which is now seen to be compounded by human conduct and misconduct as well, and also as an interpreter of the outside economic world to the internal organizations. It should now be clear that, if the foregoing observations are reasonably accurate, then two primary qualifications for successful executive performance are (1) the ability to make rapid and accurate estimates of both the long-term and short-term economic effects of any decision made in settling internal disputes and (2) the ability to make rapid and accurate esimates of human behavior as exhibited by the persons with whom the executive is obliged to deal. The first qualification—that of having business sense—is rather obvious, but I would like to make a brief examination of the second qualification—the ability to appraise human nature.

THE TENDENCY TO GIVE PERSONAL INTERESTS PRIORITY

One of the most conspicuous features of human nature is the tendency, in every person, to take care of his own personal interests ahead of everything else, or, in the words of William Temple: "We estimate the value and importance of things by the way in which they affect ourselves." This observation may readily be confirmed by examining the behavior of ourselves and those around us. It means that every job of assignment in the industrial world is looked upon by the individual as an opportunity for self-advancement in some direction or another. According to traditional Christian thought we are born this way.

Another conspicuous facet of human nature is the ability of man, on occasion, to sacrifice his own personal welfare to some larger interest involving the welfare of other humans In general, the individual does this by setting aside his own selfish objectives and embarking on a course of action which clearly benefits his neighbors at least as much as, if not more than, himself. Christian tradition teaches that this latter behavior is not only the happier and more desirable one, but is also man's divine destiny. Man's finest hours are those which contain the greatest acts of self-sacrifice.

For most of us, life is a constant choosing between selfish and sacrificial acts. In most instances the choices are unconsciously made; in fact, we are scarcely ever aware of making deliberate choice. But in those rare moments of reflection when we look back upon a long succession of such choices and see what direction our lives are taking, then the conflict becomes all too clear. Practically, every act is seen to be a compromise containing both elements in some degree, and often so inextricably mixed that it is beyond our power as individuals to sort them out completely. Frequently we end up trying to rationalize each situation in terms of its ultimate effect on the opinion of other persons toward ourselves, quite apart from the selfish or sacrificial aspects of the case.

With these thoughts about human nature in mind, let us return to a consideration of the executive who is resolving the internal conflicts of the industrial firm.

The executive's actual method of operation is very much like that of the abbot in a Benedictine monastery. Saint Benedict, you may recall, founded the monastic order which bears his name about 529 A.D. The Benedictines lived a life which was devoted partly to worship and meditation, and partly to useful physical labor; but the thing which is most pertinent to us is that the work schedule and government of this organization was completely codified in a document known as the Benedictine Rule. According to the Rule, the abbot could not make a major policy decision without first personally securing the opinion of every member from the youngest to the oldest. He was not obligated to follow any of these opinions in reaching a conclusion, but, since he was also held accountable to God for his management of the group, a conscientious abbot could not wilfully ignore good counsel, regardless of the source.

The twentieth century executive, like the Benedictine abbot, gathers the opinions of those around him before taking a major step. The opinion-gathering process may be formal—conference style—or it may be informal—in restaurants, on trains or planes while traveling, or in a barroom where some persons talk more freely. There is no guarantee that the executive will heed any of this advice in taking a subsequent action, but even the most arbitrary and dictatorial operator does, by some means, discover the thought patterns of those around him. He is not only accountable to God, but he is also accountable to a board of directors or a president for his action, so he cannot afford to get too far out on a limb by himself; his success depends to a large degree on the loyalty of his subordinates in carrying out executive policy.

EXECUTIVE MUST WEIGH ENGINEERING WITH OTHER OPINIONS

Taking into account, now, the series of problems stated earlier, it is clear that the executive will be obliged to weigh engineering opinion along with opinion about markets, production schedules and competitor's behavior in reaching a judgment. Furthermore, these opinions are all being expressed by human beings whose human nature prompts them to act both selfishly and sacrificially and in ever-varying degrees. You may have the impression that engineering is an exact science because of the great number of academic problems having unique solutions. Let me assure you, however, that real life technical problems have a multitude of solutions, depending on the criteria of judgment which may be applied. Engineers are just as likely to take selfish or narrow-minded positions as any other human being. Consequently, no executive will hear much of what you have to say as an engineer until he finds out what kind of person you are.

Problem solving for the executive thus becomes a continuous analysis of the human beings around him. His situation is complicated by the fact that he must, in the same stroke, analyze himself. Human problems seem more insoluble than the technical or economic ones because of the fact that where judgments of human value are being made, the judgments are being rendered by agents who are themselves human, and thus subject to the same temptations and errors of thought as those on whom the judgments are being passed. It follows, almost without saying, that those who are

gifted with the ability to make such difficult judgments intuitively possess something which is beyond the power of any educational process to bestow.

A further interesting point is that the executive faculty changes very little, if at all, through the years. Julius Caesar, for example, could probably fill Dwight Eisenhower's post in less time than it would take him to learn to speak English, but Archimedes would undoubtedly flounder for years with a research assignment in atomic fission.

Earlier in this paper, I suggested certain political analogies as being illustrative of what takes place in the industrial firm. It is now only a short step further to suggest that the corporation executive may also be described as a politician.

Politics is a two-faced term; it may be used to describe that kind of management of public affairs which, in the higher sense, we prefer to call statesmanship; or, as it is frequently used, to describe that kind of mismanagement of public affairs which occurs when officials serve their own personal ambitions ahead of the public welfare. Since the actual case contains both elements, it is not surprising to find the New International Encyclopaedia defining politics as "the struggle for personal authority in an organized community, as well as the struggle for the maintenance of the power of the whole state." Using this basic definition, it is but another short step to suggest that human activity in industry may be summed up as "the struggle for personal authority in an organized management, as well as the struggle for the maintenance of the competitive position of the whole firm." Managerial persons become politicians not by deliberate choice, but by virtue of the fact that they are human beings in positions of authority.

RELATIONSHIP BETWEEN CURRICULUM AND PRACTICE

One more segment and the circle of political analogies will be completely closed.

If you now ask, "Can a lawyer then become a successful executive in the industrial firm?", then my answer is: "They not only can, but do." The works manager of the plant you visited this afternoon is a lawyer by training and with a background in industrial relations.

Going back now to the original object of this inquiry—to establish a clearer relationship between the comprehensive curriculum and the realities of engineering practice—we are now in a position to close the gap on at least one point. We have, in the past few minutes, touched very, very lightly but, I hope, meaningfully, on the fields of psychology, theology, sociology, political science, history, economics and anthropology. With the aid of these sciences, we learn to understand the social and industrial context in which we, as engineers, are going to carry on our life's work. In particular, these sciences enable us to understand the role of the executive whose policies will dominate the environment in which you work. Understanding, however, does not automatically qualify you to fill an executive post any more than the preparation of this paper qualifies me for the presidency of General Motors. Education is no substitute for native ability. It does enhance and broaden that ability whenever the two happen to coincide.

I suspect that some of you may think of my remarks as just so much double talk—thoroughly confusing. On this account, let me make two more observations.

First, it is always difficult to assimilate information about a process which you have never experienced. But, once experienced, the same information redigested takes on new and added significance. I predict that practically every one of you will go completely through your first industrial squabble without realizing that the issue which you joined in heated argument did not originate with your entry on the scene, but was inherent in the industrial system itself. The realization will come only in those moments of reflection when you are able to take a dispassionate view of the whole sequence of events. This realization may not come until after you have weathered several industrial storms, but when it does come, then you will know that the personal thrusts and the petty maneuverings which may have absorbed so much of your attention are but a waste of energy in the final outcome. No industrial issue is ever settled by making a fool of somebody, regardless of how much you think he may deserve such a fate. It may come back to haunt you later on.

The second observation is that the academic presentation of these cultural courses may not seem to be germane to the industrial scene which I have been describing to you. This is mainly due to the fact that very few of these courses are tailored to your particular needs and are still in the process of growing into useful sciences. Let me illustrate this point in the field of anthropology. The opening paragraph of Ruth Benedict's "Patterns of Culture" goes this way: "Anthropology is the study of human beings as creatures of society. It fastens its attention upon those physical characteristics and industrial techniques, those conventions and values, which distinguish one community from all others that belong to a different tradition." On this view, boards of directors and university faculties are legitimate objects of anthropological investigation, but I fear that most of the subtitles of the anthropology courses which you may be offered suggest "The American Indian" or "Primitive Man" as the actual course material. These are perfectly valid fields, but they will not have much significance for you until they are linked up with our own cultural system in such a way as to throw a perspective light on our own revered practices. Malinowski calls this functional anthropology.

CULTURAL COURSES FOR ENGINEERING STUDENTS ADVISED

I advise you to take these cultural courses regardless of their state of development on your particular campus. The material you get will be useful in enabling you to recognize and appreciate later developments whenever and wherever you happen to find them in later years.

This brings me to my concluding thought—that your education in these fields must continue throughout your life. Your own perspective on these topics is going to change with increasing age and experience and you can never afford to feel that you know all there is to know about the study of mankind. Sir James Frazer's "The Golden Bough" may be dry as dust today, but a thrilling and revealing adventure ten or twenty years from now.

In closing, let me recommend two books which should be stimulating reading at any age. The first is an anthropological novel published just last year and available on many newstands in a paper-bound edition at 35 cents. It is "Executive Suite" by Cameron Hawley. The other is a survey of the present state of the cultural sciences and is entitled "The Proper Study of Mankind" by Stuart Chase. But even with these aids, you will have to utilize your own powers of observation in realizing their full import. Your industrial education has barely begun.

Comparative Performance of Farm Tractor Tires Weighted with Liquid and Wheel Weights

I. F. Reed, C. A. Reaves, and J. W. Shields
MEMBER ASAE ASSOC. MEMBER MEMBER ASAE

ONE phase of the tests by the Division of Farm Machinery of the U.S. Department of Agriculture designed to study the basic features of tractor tire design, use practices, and performance in different soils and under different conditions is reported in this paper. The preliminary part of this study on the effect of type of ballast on tractor tire performance was made cooperatively with the United States Rubber Company and was reported in a paper of this same title by J. W. Shields and I. F. Reed at the ASAE Winter Meeting in 1950. That paper, however, was not published as the data available at that time did not cover enough conditions.

A statement of problems indicating the need for controlled tests to determine the effects of design and operation factors on tractor tire performance and a discussion of the equipment developed at the U. S. Tillage Machinery Laboratory were presented by Reed and Berry (1)* at the 1948 Winter Meeting of ASAE. The test machine and dynamometers were explained by Shields (2) at the ASAE Annual Meeting in 1949. This was followed by the presentation of two papers by Reed and Shields (3) at the Society of Automotive Engineers national tractor meeting in September, 1950,giving results of studies on the effects of lug height and rim width. Results of a comprehensive study of the effects of rim width on tractor tire performance were reported by McKibben, Reed, and Reaves (4) in a paper presented at the ASAE Annual Meeting in June 1952.

Many field tests have been made by Sauve, McKibben, and others (5, 6, 7, 8, 9), which prove that there is a direct relation between the weight carried by tractor tires and their ability to provide traction or to pull loads. They show also that temperature changes cause marked pressure changes for water-filled tires. Practical experience on farms has demonstrated that it is necessary to add extra weight on the driving wheels of most tractors to secure adequate traction when using pneumatic tires for heavy field work. The following three methods are generally used to provide the extra weight:

1 *Wheel Weights.* The tires are inflated with air and the weight provided by use of heavy cast-iron wheels or removable wheel weights of cast iron or other heavy material.

2 *Partial Liquid Fill.* The tires are partly filled, usually to the top of the rim (75 to 83 per cent) with liquid ballast. Water or a calcium chloride solution is used. The space above the liquid is inflated with air at the desired pressure. Wheel weights may be used also if additional weight is needed.

3 *Total Liquid Fill.* The tires are completely filled with water or a calcium-chloride solution. The pressure

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at New Orleans, La., February, 1953.

The authors — I. F. REED, C. A. REAVES, and J. W. SHIELDS — respectively, senior agricultural engineer and associate agricultural engineer, Division of Farm Machinery (BPISAE), U. S. Department of Agriculture (Tillage Machinery Laboratory), and manager, Farm Tire Division, Tire Development Department, United States Rubber Co.

Author's Note: The authors acknowledge the helpful suggestions and guidance of E. G. McKibben and others.

*Numbers in parentheses refer to the appended references.

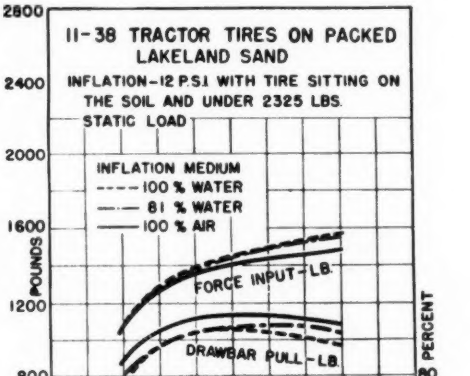


Fig. 1 The effects of three types of ballast on the performance of tractor tires in packed Lakeland sand. Inflation pressures were measured at the tire valve

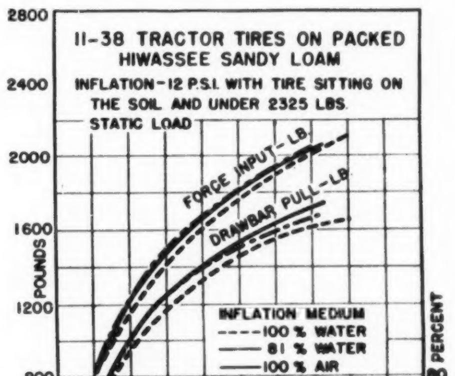


Fig. 2 The effects of three types of ballast on the performance of tractor tires in packed Hiwassee sandy loam. Inflation pressures were measured at the tire valve

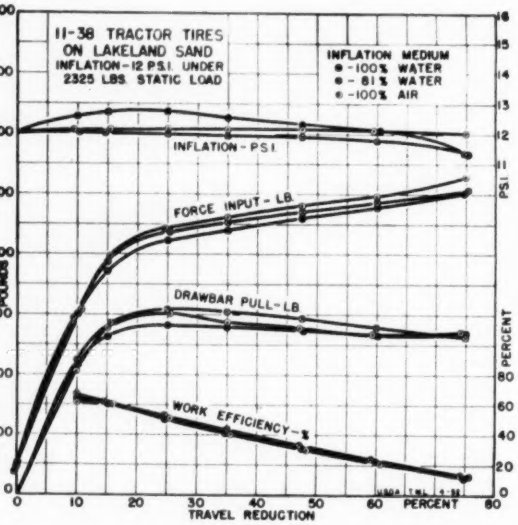


Fig. 3 The effects of three types of ballast on the performance of tractor tires in packed Lakeland sand

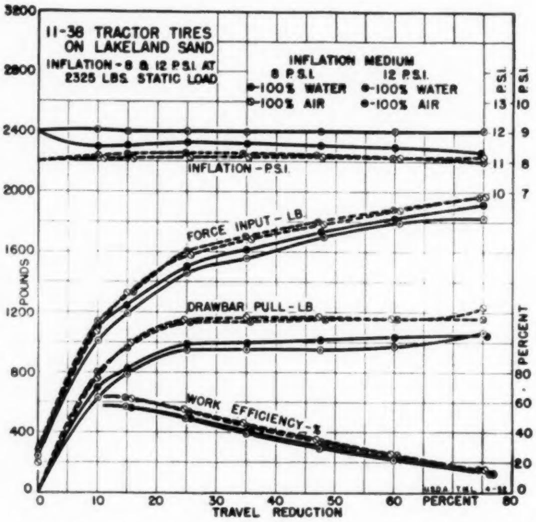


Fig. 4 The effects of two types of ballast on the performance of tractor tires at two inflation pressures in loose Lakeland sand

of the liquid is adjusted to match the Tire and Rim Association recommended inflation pressure.

Tests reported in this paper were made to determine the relative effectiveness and efficiency of these three methods. The scope of this report is limited strictly to tire performance with no attempt to evaluate the advantages or disadvantages of the different methods as to initial cost, tire life, bounce, convenience, or the effects produced in or on the soil.

Three commercially identical U. S. Royal 11-38, 4-ply, bar-type tractor tires were mounted on W10-38 rims. One tire was inflated with air, another was filled to the top of the rim (81 per cent) with water, then inflated with air, and the other was filled (100 per cent) with water to the predetermined inflation pressure for each test. Wheel weights were added to the air-filled and 81 per cent liquid-filled tires to bring their weights up to that for 100 per cent liquid-filled tire. The total static load carried by each of the three tires as tested was 2325 lb. Instruments on the test unit automatically recorded torque input, drawbar pull, forward travel, and wheel rotation for all tests. The tractor was operated in low gear with the engine at 1400 rpm for all tests. The rolling radius was determined for each tire in each soil with a total load of 2325 lb and with no drawbar pull. The term "force input" as used in this paper is torque in foot-pounds input at the hub of the wheel, divided by the rolling radius. Work efficiency is (drawbar pull ÷ force input) x (100 per cent travel reduction). A relatively complete description of the soils and methods of preparing and test procedure is given by McKibben, Reed, and Reaves (4).

The tests logically divide into two series. The first series was reported in a paper at the 1950 ASAE Winter Meeting by Shields and Reed. Tests were made in only two soils, packed Lakeland sand and Hiwassee sandy loam The pressure in each tire was adjusted to 12 psi with tire sitting on the test soil and the valve at its lowest position. The second series of tests varied from the first in that inflation pressures reported were the pressure at the bottom of the tire while under load. Provision was made for measuring and recording the inflation pressure for all tires while in operation. Inflation pressure at the bottom of the tires was obtained for the tires containing water by adding to the gage pressure the pressure due to a column of water from the gage to the bottom of the tire. Tests were made in Lakeland sand, Hiwassee sandy loam, and Decatur clay and on concrete.

SERIES 1 TESTS

The data for the tests in series 1 are shown in Figs. 1and 2. The air-filled tire gave the best performance and the 100 per cent water-filled tire gave the poorest in both soils. This relative performance holds for travel reduction, work efficiency, rolling resistance, and drawbar pull. Table 1 is data from the graphs and shows the performance of the tires in the two soils at relatively heavy drawbar loads.

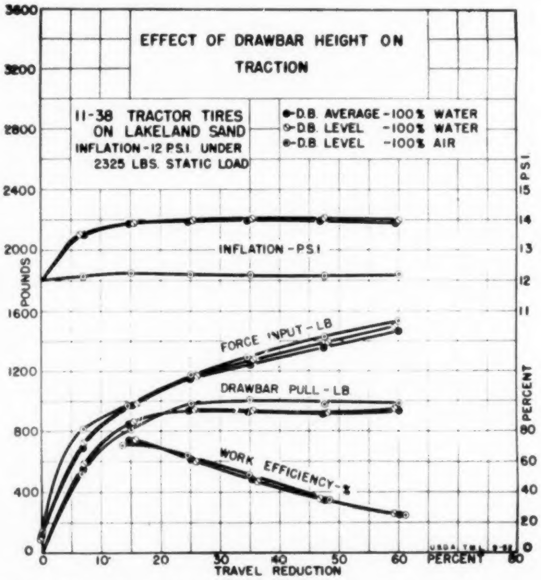


Fig. 5 The effect of drawbar height on performance of tires weighted with three types of ballast in loose Lakeland sand

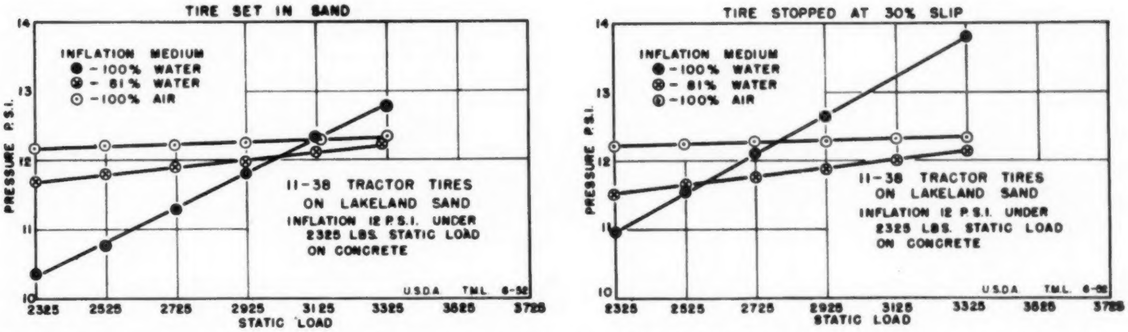


Fig. 6 The increases in inflation pressures with increases in static load for tires with three types of ballast—*(left)* with the tires setting on loose sand and *(right)* with the tires in a track made while slipping 30 per cent

The maximum drawbar pull for the sand as used for these tests was 1133 lb for the air-filled tire but was only 1085 and 1050 lb, respectively, for the 81 per cent and 100 per cent water-filled tires. The conclusion indicated by these data is that the air-filled tire, with wheel weights, was more efficient and more effective than either the 100 per cent water-filled or partially water-filled tires in these soil conditions.

A question arose as to what caused this variation in effectiveness. Tire prints and other measurements failed to give any clue. McKibben, Reed, and Reaves (4) reported that reducing the inflation pressure from 12 psi to 8 psi increased the drawbar pull markedly for 14-26-in tires in loose sand. Could it be then that, though the inflation pressure as measured was the same at the start of the test, it changed less during tests in the air-filled tire than in the others? The inflation pressure reported for these series of tests were those read from the gage without correction for the height of water column from the bottom of the tire to the level of the gage. The tests in series 2 were made to measure the changes in pressures in tractor tires during operation and to determine the effects of these changes and other factors on their effectiveness and efficiency in three soils and on concrete.

TABLE 1. PERFORMANCE OF THREE TIRES IN TWO SOILS AT SELECTED LOADS

Type inflation	Soil type	Type drawbar pull, lb	Rolling resistance lb	Soil Travel reduction %	Drawbar Work efficiency %
Air	Sand	1000	210	13.4	71.8
81% water	Sand	1000	320	16.3	63.2
100% water	Sand	1000	325	16.5	62.9
Air	Loam	1400	240	19.2	69.1
81% water	Loam	1400	275	20.2	66.7
100% water	Loam	1400	320	23.6	62.0

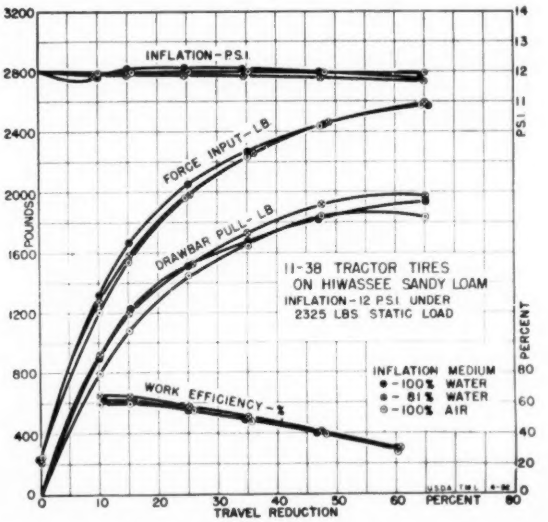


Fig. 7 The effects of three types of ballast on the performance of tractor tires in loose Hiwassee sandy loam

SERIES 2 TEST

The soils used in this series of tests were cross-tilled and the surface left loose for all tests except for the sand used for the tests in Fig. 3. This soil was subsurface packed

TABLE 2. SOIL AND CONDITION FOR TESTS

Fig.	Soil type	Per cent moisture	Bulk density
1	Lakeland sand	6.1	1.58
2	" "	6.2	1.41
3	" "	3.1	1.45
4	" "	3.3	1.36
5	Hiwassee sand loam	12.8	1.30
6	Decatur clay loam	16.4	1.30

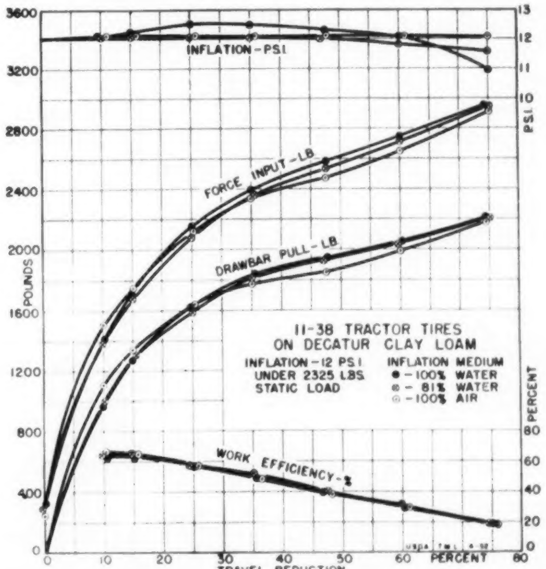
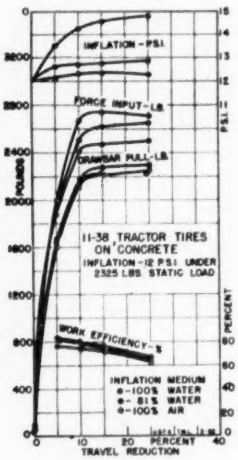


Fig. 8 The effects of three types of ballast on the performance of tractor tires in loose Decatur clay loam



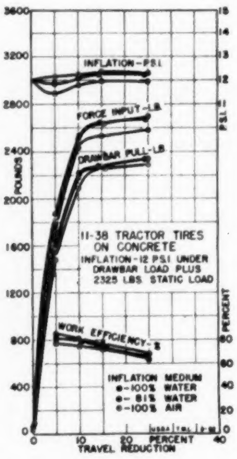


Fig. 9 (*Left*) The effects of three types of ballast on the performance of tractor tires on concrete. The inflation pressure was adjusted to 12 psi with the tire under static load and setting on the concrete • Fig. 10 (*right*) Same as for Fig. 9, except that the inflation pressure was adjusted to give 12 psi in each tire when it was operating

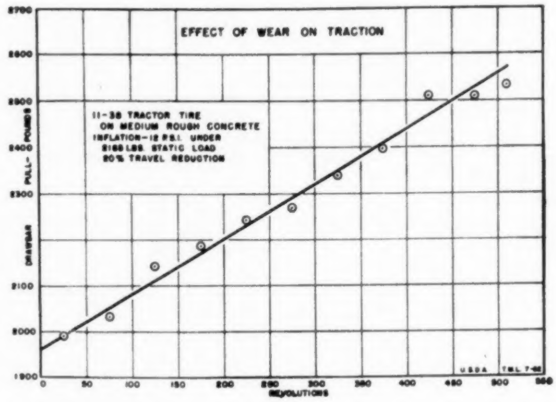


Fig. 11 The increase in drawbar with use for a tractor tire slipping 20 per cent on concrete

and rolled with a surface roller. (In this series of tests each point on each curve represents the average of not less than three replications.)

Tests in Lakeland Sand. Differences in performance of a tire shown by the data in Figs. 3 to 5 are due to variations in the conditions of the Lakeland sand. These variations and the conditions for the other soils used in these tests are shown in Table 2. The data for the tests in Lakeland sand show that the drawbar pull for loads producing slippages in the normal operating range, up to 25 per cent, is higher for the tires containing all or part air in the condition for Fig. 3, but there is little difference in the loads pulled or work efficiencies for the other tests in this soil.

The inflation curves in Figs. 3 and 4 show that when the inflation pressure of a 100 per cent water-filled tire is adjusted to 12 psi, under a static load of 2325 lb with the tire resting on concrete, the inflation pressure increases when the tire is operated on packed sand as the slippage increases to 25 per cent, then drops off until it is back to 12 psi at 60 per cent slippage. When the inflation pressure is adjusted with the loaded tire on concrete and the tire is used in loose soil, the pressure will decrease slightly or remain constant as shown in Fig. 4. If, however, the inflation pressure is adjusted to 12 psi with the tire on the loose soil, the pressure increases as shown in Fig. 5. It is indicated that the decrease in pressure for the higher slippages in Fig. 3 happens when the tire has dug through the packed layer of soil. The pressure changes in the air-filled tire were not enough to be effective for the three conditions. Pressure changes for the 81 per cent water-filled tire tended to be near those for the 100 per cent air tire except when adjusted to pressure while in loose soil.

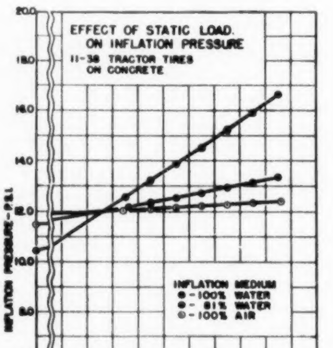


Fig. 12 The increases in inflation pressure for tires filled with air, 81 per cent water, and 100 per cent water when the static load was varied from zero to 3700 lb. Initial inflation was 12 psi with the tire on concrete and a static load of 2325 lb

The data in Fig. 4 show that, though not recommended by the Tire and Rim Association, reducing inflation pressure to 8 psi increases both the drawbar pull and work efficiency of the tires. Air-filled and water-filled tires carrying the same effective weight performed alike in the loose sand at 8 psi inflation.

The data in Figs. 3 and 4 were obtained with the hitch on the test car set to make the hitch link to the tractor level at the dig-in due to about 25 per cent slip. Since the tires dug in much more at the higher slips, a motor drive was arranged to enable raising or lowering the hitch point to keep the link to the tractor level for all load conditions. The data in Fig. 5 show that the angle of hitch caused by the tire digging in did not measurably affect the tire's effectiveness.

Fig. 6 shows that the increase in inflation pressure due to adding static load was greater when the tire was setting in a track made when slipping about 30 per cent than when on dry loose soil. This is explained by the fact that the tire is on firmer soil in the track and is borne out by Fig. 12 which shows an even greater increase per unit of weight for a tire on concrete.

Tests in Hiwassee Sandy Loam and Decatur Clay Loam. The inflation medium had little effect on the performance of the tires in these two soils. Though neither soil was packed after cross-tilling, the heavier Decatur clay loam caused a slight increase in inflation pressure for the water-filled tire as the load was applied through the normal operating range.

Tests on Concrete. The tires with the three types of ballast were tested on the medium rough concrete test track with the results shown in Figs. 9 and 10. When the inflation pressure was adjusted to 12 psi with the tire on the

concrete, as for Fig. 9, the inflation pressure increased with load for all tires. The increase was slight for the air-filled tire, was more for the tire containing 81 per cent water, and was nearly 3 psi for 100 per cent water-filled tire at 25 per cent slip. Under these conditions, the 100 per cent water-filled tire outperformed the other tires. This then left the question, was the better performance of the 100 per cent water-filled tire due to the higher inflation pressure or to the type of ballast? A series of tests was then made in which the pressure was adjusted in each tire so that it was nearly as possible at 12 psi when loaded with the static load plus drawbar pull. Data for these tests are shown in Fig. 10. Under this condition the drawbar pull for each of the three tires were nearly equal.

A study of Figs. 9 and 10 shows that the drawbar pull for the 100 per cent water-filled tire remained nearly constant for the two series of tests and the drawbar pulls for the air-filled and 81 per cent water-filled tires increased. Why should the output for these two tires increase when no changes were made in these tires, particularly the air-filled tire? The only change was to lower the inflation pressure in the 100 per cent water-filled tire. The explanation is shown in Fig. 11. A new tire was operated 500 revolutions at 20 per cent slip on the concrete track. The drawbar output increased steadily throughout this study, indicating that wearing the sharp edges off the lugs gave them a firmer grip on the concrete surface. Thus the change in inflation pressures for the 100 per cent water-filled tire offset the increase in drawbar pull that would have been produced due to tire wear and the normal increase due to wear for the other tires brought them up as shown.

Inflation pressures produced by static loads varying from zero to 3700 lb for the air-filled, 81 per cent water-filled, and 100 per cent water-filled tires with the initial inflation adjusted to 12 psi with the tire on concrete and static load of 2325 lb are shown in Fig. 12. The inflation pressure varies from 3 psi for no load to about 16.8 psi at 3700 lb for the 100 per cent water-filled tire. The pressure in the air-filled tire varied from 11.5 to 12.4 psi and the pressure in the 81 per cent water-filled tire varied from 10.4 to 13.4 for this same range of loads.

In Fig. 13 the increase in inflation pressures for the three tires is shown for loads applied to the tire. For this study the test car was locked so that there was no travel and the load applied to the tire through the tractor-gear mechanism. Loads increasing by increments to 1400 lb, then decreasing in the same way to zero, were applied. Weight transfer for the loads is shown also. The increases in

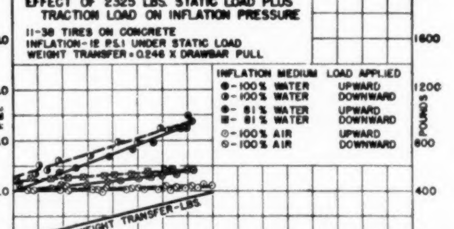


Fig. 13 The increases in inflation due to drawbar pull for the tires used in Fig. 12

inflation pressures due to the applied drawbar loads are greater than the increases that would be caused by the weight transfer for the respective drawbar loads. For example, the weight transfer for an 800-lb drawbar load, Fig. 13 is about 200 lb. The increase in inflation pressure for the 100 per cent water-filled tire is about 1.7 psi. The curve in Fig. 12 shows that an increase of 200 lb in static load would increase inflation pressures only about 0.9 psi. The remaining 0.8 psi increase is apparently due to the distortion of the tire caused by the tractive effort which tends to rotate the tread of the tire with respect to the rim, thus tending to reduce the volume and increase pressure.

SUMMARY

The effectiveness of tractor tires is markedly affected by the effective pressure at the bottom of the tire while under load. Higher pressures, whether caused by air or liquid, reduce the tire's effectiveness in loose sandy soils but increase effectiveness on concrete and extremely firm soils. The inflation pressure in air-filled tires does not change appreciably with changes in loads. The inflation pressure in the 100 per cent water-filled tire changes as much as 3 psi (which was 25 per cent) for the scope of this study. The inflation pressure does not change appreciably for tires inflated while sitting on concrete, then operated in loose sand, Fig. 4. However, if the inflation is checked with the tire sitting on the media on which it is to be operated, it increases with the application of drawbar loads within the normal operating range for tires containing all or part liquid, as shown in Figs. 5 and 9. Thus the better performance of the air-inflated tire as compared to the tires containing liquid shown in Figs. 1 and 2 is due to the higher inflation pressures during operation in the tires containing liquid. Since the inflation pressures for these tests were measured at the valve with the tires sitting on the test soil, the data in Figs. 3 to 8 show that the pressure in the water-filled tire rose between 2 and 2.5 psi higher during operation than the pressure in the air-filled tire. Other studies have shown, and it was noted during this study, that temperature changes caused large fluctuations in the pressure of 100 liquid-filled tires but had little effect on the air-filled tires.

These tests show that the type of ballast did not affect the tire's effectiveness if the static load on the tire and inflation at the bottom of the tire were the same for the respective tires. It is indicated that inflation pressures for the tires containing liquid should be measured with the tire under its normal static load and sitting on concrete or some other firm base and that it should be the recommended gage pressure for aid inflation less the pressure due to the column of liquid from the valve to the bottom of the tire for liquid-filled tires to be as effective as air-filled tires in loose soils.

REFERENCES

1 Reed, I. F. and Berry, M. O. Equipment and Procedures for Farm Tractor Tire Studies Under Controlled Condition. AGRICULTURING ENGINEERING, vol. 30, February, 1949.

2. Shields, J. W. Electric Dynamometer for Testing Tractor Tires. AGRICULTURAL ENGINEERING, vol. 20, September, 1949.

3 Reed, I. F. and Shields, J. W. Effect of Lug Height and of Rim Width on the Performance of Farm Tractor Tires. SAE Journal, vol. 58, December, 1950.

4 McKibben, E. G., Reed, I. F., and Reaves, C. A. Effect of Rim Width on Tractor Tire Performance. AGRICULTURAL ENGINEERING, vol. 33, August, 1952. *(Continued on page 399)*

Design of Semiclosed Pipe Systems for Irrigation Water Distribution

Edward H. Taylor and Arthur F. Pillsbury
MEMBER ASAE

MOST irrigation water is distributed to farms and on farms in canals and ditches. Recently, with increasing scarcity of water and with greater recognition of the fact that "ample" water may mean wasted water and drainage problems, there has been wider recognition of the value of concrete-pipe irrigation distribution systems. These have long been common in California, especially in southern California. In recent years there has been an improvement in some farm pipe line designs that can well be used more generally, especially for district distribution. It involves the adoption of a semiclosed system through use of float valves. The potentialities of the semiclosed system are greater for district distribution than for farm distribution (2, 5)*.

The concrete irrigation pipe used on farms is not reinforced so pressures must be kept low. When properly installed it should give excellent service at reasonable cost. Main difficulties have always occurred on the steeper slopes where drop or check structures must be installed to obtain flow from upper hydrants and/or prevent excessive pressures downstream. These control structures take the form of overflow stands (Fig. 1—A, B and C). Any water not taken out by upstream hydrants overpours the baffle in the overflow stand and continues downstream. It is usual to provide for regulatory wastage at the lower end. However, pressures are never excessive, usually within the range of 4 to 12 ft, and adequate, relatively uniform, pressure is available for operation of hydrants and/or laterals upstream from each overflow stand. Difficulty occurs because the water falling over the baffles entrains air and surges result† (2, 3). To overcome this difficulty it is usually necessary to install a gate valve between the upstream and the downstream portions of the stand (Fig. 1-B). In operation, the gate is closed just enough to raise the upstream water surface about to the baffle level with little or no overpour. There is no air entrainment, but the automatic features of the system are lost. Sloping downpour sections, or wide lips with large downpour area (Fig. 1-C) have helped on some small farm systems (3), but have not been successful on large systems (4).

Float Valves for Semiclosed Systems. In the newer semiclosed systems, float valves replace the baffles of overflow stands (Fig. 2). Then, like the closed system, only as much water is admitted down the line as hydrants and/or laterals are open to discharge. There is no waste water. There is advantage over the closed system in that pressures are always controlled, giving good regulation of hydrant or delivery discharge, and permitting use of inexpensive non-reinforced pipe. Thus the best features of the open and closed systems are combined. Another feature, too little recognized by engineers, is that, with some upstream regulatory storage, the farmer has far greater flexibility in the taking of water than is possible with the open system (except possibly in periods of peak demand). Greater flexibility should improve farmer relations, conserve water, and lessen drainage problems.

Early float valves, when set up in series, caused unsteady flow because of the tendency of the valves to hunt (when any turbulence existed in a stand). Such unsteady flow was often amplified at each successive reach downstream. This hunting was eliminated on farm installations merely by changing the response of the valves, providing for 6 to 12 in difference in float elevation between open and closed

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors — EDWARD H. TAYLOR and ARTHUR F. PILLSBURY — are, respectively, associate professor of engineering and professor of irrigation, University of California, Los Angeles.

*Numbers in parentheses refer to the appended references.

†On one district system it has been found that surge occurs whenever the downstream pipe line is flowing full clear up to the stand and the overpour exceeds 2.5 to 3.0 ft. (Coachella Valley County Water District, Keith Ainsworth, watermaster.)

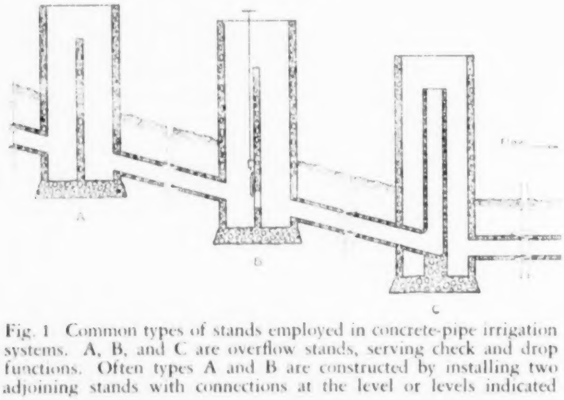


Fig. 1 Common types of stands employed in concrete-pipe irrigation systems. A, B, and C are overflow stands, serving check and drop functions. Often types A and B are constructed by installing two adjoining stands with connections at the level or levels indicated

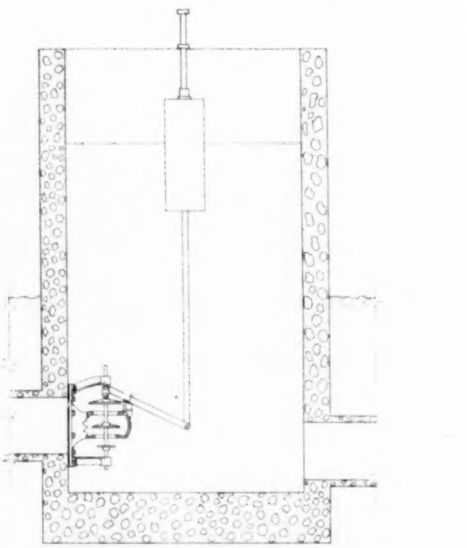


Fig. 2 A float-valve stand. There would be a series of these at regular intervals in a semiclosed system, each letting water flow down as regulated by the height of water in the stand

positions of the valves. Linkage and/or a tall, small diameter float have been used to insure operational stability. (Periodic air traps acting as surge chambers have dampened out hunting, but have been unnecessary in field installations.)

Diaphragm valves were early used for float valves. The upstream water pressure was piped to the diaphragm chamber, which expanded the diaphragm and closed the disk. The float actuated a bleeder valve on the diaphragm chamber, the bleeder valve opening when the float dropped, thus lowering pressure in the diaphragm chamber and permitting the disk to be pushed open by the discharging water. It was difficult to dampen response of these valves, and small solid particles often partially clogged the small pipe to the diaphragm chamber or the bleeder valve. Their use was discontinued, as was use of a combination diaphragm-mechanical valve. A sleeve valve was then tried. Balance, to minimize float size, was attained by a self-sealing rubber gasket around the sleeve. This valve worked satisfactorily if heads did not exceed about 12 ft. At higher pressures the gasket tended to stick.

Valves at present in commercial production are of two types. One is a single-disk open valve (Fig. 3). The large opening permits trash to pass readily with little danger of clogging. The disk must withstand the entire upstream pressure. Usual empirical design requires that the total velocity head plus pressure head on the disk equal the weight of water displaced when about half of the float is submerged. The other type of valve is a double disk-balanced valve. At least four different makes of these have been manufactured in southern California. Fig. 2 shows one make, and Fig. 4 shows another being installed in a typical stand. This type is said to be "balanced" because the water pressure tends to open one disk and close the other. Thus the float need be large enough only to overcome friction, plus a factor of safety, and is essentially independent of water pressure.

Some float valves are made for watertight closure, but most are not, being primarily devices to control rate of flow and not achieve complete shutoff. When complete shutoff is provided, and a mechanical device is included to keep it closed, it may be possible to eliminate the one or more gate valves required on each lateral. When there is not need for complete regulation (i.e., when there will always be a certain minimum flow for which automatic regulation is not needed), it may be possible to place a manual gate valve in parallel with the float valve. This can reduce the size of float valve required and so reduce the cost of the installation. If this is done, a careful appraisal of the proposed operational procedures is more necessary when designing the system and intelligent operation is required thereafter.

Losses in Float Valves. In designing a system for sizes of float valves required, the essential thing is to know the pressure-discharge relationships with valves full open. Thus it will be known that the required maximum flow can be attained with the pressure loss available. Information on this essential relationship has been lacking. Therefore, the authors ran such tests on the common farm-type valves in the fluid mechanics laboratory, college of engineering, University of California, Los Angeles. Flow rate was determined gravametrically. Fig. 5 shows the results of such tests. The relationships derived from these tests follow:

Size, in*	Diameter of port, in	Net port area, sq ft†	Ratio of net port area and nominal port area‡	Formula§	Value of C in $h = C(V^2/2g)$‖
		Single-disk open type			
4	4.125	0.093	1.06	$h = 4.26Q^2$†	2.37
5	4.846	0.128	0.94	$h = 2.24Q^2$†	2.36
8	7.985	0.349	1.00	$h = 0.30Q^2$†	2.35
		Double-disk balanced type			
4	3 & 2¾	0.086	0.99	$h = 10.4Q^2$†	4.94
6	4⅜ & 4⅛	0.192	0.98	$h = 1.85Q^2$†	4.39
8	6 & 5⅞	0.362	1.04	$h = 0.50Q^2$†	4.21
8	8¼ & 6	0.561	1.61	$h = 0.34Q^2$†	6.88

*Nominal diameter of pipe to which attached.

†Computed on basis of actual port diameters as given less cross-sectional area of any rods extending through ports (double-disk type).

‡Nominal port area based on nominal diameter of pipe to which attached.

§h = head loss in feet of water with valve wide open; Q = flow in cubic feet per second.

‖With velocity computed on basis of net port area given.

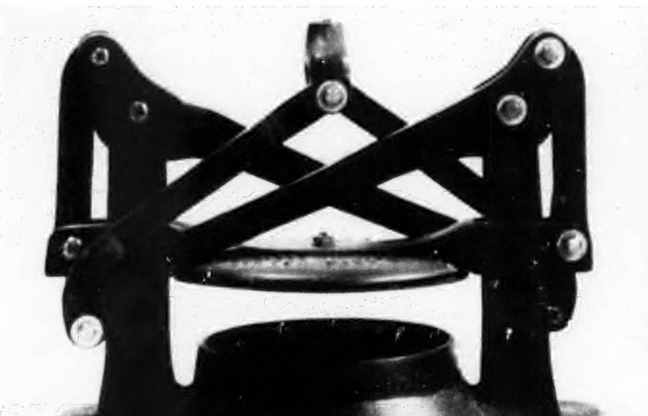


Fig. 3 *(Left)* A single-disk, open-type float valve, without float • Fig. 4 *(Right)* Installing a double-disk, balanced-type float valve in a farm concrete-pipe irrigation system

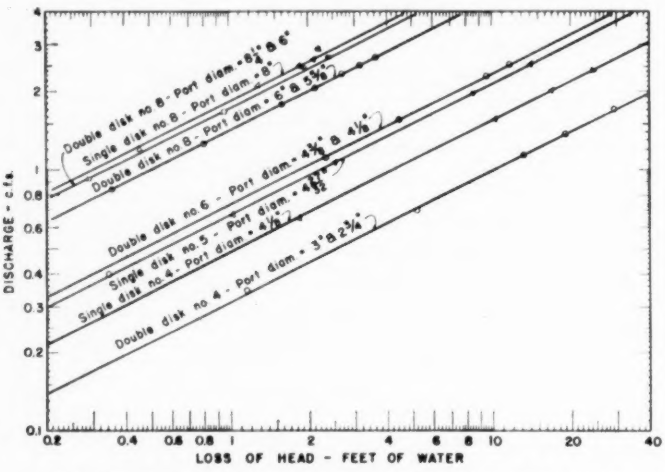


Fig. 5 Results of tests of pressure-discharge relationships of the common commercial farm types of float valves when wide open

It may often be necessary to extrapolate the results of these tests to estimate the wide open losses through larger valves. (The valves are now made in sizes up to 30-in.) With due regard to the hydraulic similarity of the valves, largely as indicated by the type and the ratio between net port area and nominal port area, and with due regard to the value of C in the table above, this can undoubtedly be done with reasonable accuracy.

Notes on the Mechanics of Float Valves. Some insight into the mechanics of float-valve operation may be obtained from the following crude example:

Consider the discharge of water from an unlimited supply at constant head H into a standpipe in which the head is h as indicated in Fig. 6. Suppose that Q_o is a steady rate of discharge at which the valve is wide open (the valve area being $\pi d Z_o$) and Q_o takes place under head $H-h_o$. Under this condition the float exerts no net buoyant force. The valve operates when the efflux is reduced from Q_o to a lower steady value Q_e. Suppose further that there are no hydro-dynamic forces acting on the valve, that is, that it is perfectly balanced.

Neglecting lateral motions, take Z as the coordinate of the valve position, so designated that the inlet area A_i is $\pi d\ (Z_o-Z)$.

In order to simplify the analysis to follow, the assumption is made that the frictional resistance to operation is directly proportional to the velocity of operation of the valve. This assumption will permit the drawing of certain qualitative conclusions as to the effects of the linkage ratio α : 1 and of float proportions.

Suppose now that the efflux is reduced from Q_o to a smaller value Q_e. Water will be accumulated in the stand and the continuity condition is:

$$Q_i - Q_e = (A_s - A_f)\,dh/dt \quad . \quad . \quad . \quad [1]$$

in which $Q_i = C_d A_i \sqrt{2g(H-h)}$ and where C_d = a discharge coefficient.

$$A_i = \text{inlet area of valve} = \pi d (Z_o - Z)$$

As the level rises by an amount $h-h_o$ in the stand, the float follows and moves an amount αZ. The buoyant force is proportional to the volume represented by the hatched area in Fig. 7.

The buoyant force is

$$B = w\,A_f\,[h - h_0 - \alpha Z]$$

For the float, the equation of motion then is

$$wA_f\,[h-h_0-\alpha Z] - P = M_f \alpha Z''\ddagger \quad . \quad . \quad . \quad . \quad [2]$$

in which w = unit weight of water = 62.3 lb per cu ft, and M_f = the mass of the float.

Neglecting the inertia of the linkage, the force transmitted through the linkage to the valve will be αP and the equation of motion of the valve is

$$\alpha P - CZ' = M_v Z'' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

where C = the damping factor. M_v = the mass of the valve.

Upon eliminating the linkage force P between equations [2] and [3], there is obtained

$$\alpha w\,A_f\,[h-h_0-\alpha Z] = (\alpha^2 M_f + M_v)\,Z'' + CZ' \quad [4]$$

‡Primes refer to differentiation with respect to time.

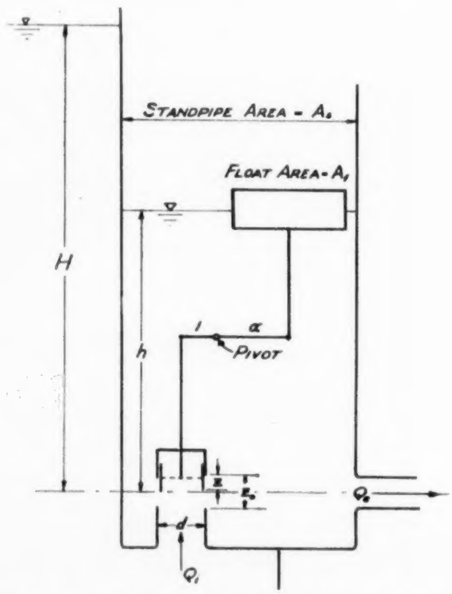


Fig. 6 Sectional elevation of a hypothetical float valve in a stand

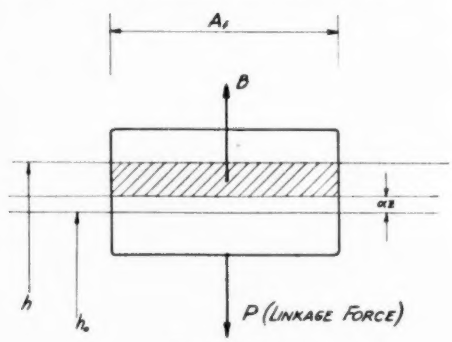


Fig. 7 A float

Returning to the continuity condition of formula [1], which may be written

$$C_d\ [\pi d(Z_0-Z)\ \sqrt{2g(H-h)}-Q_e=(A_s-A_f)(dh/dt),$$

one further simplification is made, namely, that it is supposed that the variation in standpipe level $(h-h_o)$ is small in comparison with the driving head $(H-h)$, so that the inflow can be approximated as taking place under the constant head $(H-h_o)$. The continuity equation becomes

$$k(Z_o-Z)-Q_e=(A_s-A_f)\ (dh/dt)$$

where $k=C_d\,\pi d\ \sqrt{2g(H-h_o)}$

and from which

$$dh/dt=[k(Z_o-Z)-Q_e]/A_s-A_f \quad . \quad . \quad . \quad . \quad [5]$$

The quantity h is eliminated between equations [4] and [5] by differentiating equation [4] with respect to time, with the result:

$$\alpha w\ A_f\left[\frac{k(Z_o-Z)-Q_e}{A_s-A_f}-\alpha Z'\right]=$$

$$(\alpha^2\ M_f+M_v)Z'''+C\,Z'' \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

This third-order differential equation in Z takes on the form, after suitable rearrangement,

$$Z'''+A_2\,Z''+A_1\,Z'+A_o\,Z=K\ \text{(a constant)} \quad . \quad [7]$$

in which the constant terms are as follows:

$$A_2=C/\alpha^2\ M_f+M_v$$

$$A_1=\alpha^2\ w\ A_f/\alpha^2\ M_f+M_v$$

$$A_0=(\alpha w\ A_f\ k)/(A_s-A_f)(\alpha^2\ M_f+M_v)$$

$$K=[\alpha w\,A_f(Q_o-Q_e)]/(A_s-A_f)\ (\alpha^2\ M_f+M_v)$$

The principal interest in this differential equation is not in its detailed solution, which, in view of the simplifications made, probably would not be quantitatively useful. Rather, certain trends of behavior can be discovered from a study of the coefficients. The solution equation will give Z, the valve position, as a function of the time. This equation will consist of one part giving the transient response of the valve (this is the solution of the reduced equation)

$$Z'''+A_2\,Z''+A_1\,Z'+A_0\,Z=0$$

plus a second part which is a particular integral of the entire equation. Interest here is centered on the first part, the transient response, because that will determine whether or not the valve operation will be stable or not.

J. P. Den Hartog in his text "Mechanical Vibrations" discusses this question and shows that the sole criterion for stability is that

$$A_1\,A_2>A_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [8]$$

provided that all the coefficients A are positive, which is the case here. The criterion formula [8] when the coefficients of formula [7] are inserted becomes

$$\alpha/(\alpha^2\ M_f+M_v)>(1/C)[K/(A_s-A_f)] \quad . \quad [9]$$

One sees immediately that stability may be insured by the use of a relatively tall, small-diameter float, making the term (A_s-A_f) comparatively large, thus providing satisfaction of equation [9]. On the other hand, the effect of increasing the linkage ratio α : 1 is not so immediately apparent. If, for example, the valve itself is massive in comparison with the float, increasing the ratio α will tend to increase the left-hand member of equation [9] which would tend toward the side of greater stability. However, if the float were massive in comparison with the valve, the left-hand side of equation [9] would be approximately $1/\alpha\ M_f$ and increasing the linkage would tend to cause the system to be less stable.

While the foregoing analysis is not intended to be complete in that an oversimplified flow system is taken as the example, the essential effects of linkage and float proportions are clearly shown. It is interesting to note that some friction is necessary for stable operation, for if C were set equal to zero, the criterion equation [9] could never be fulfilled.

In a real system, the hydrodynamic forces on the valve, the inertia effects of the water in the irrigation pipe, the hydraulic friction in the system should all be taken into account. The mathematics becomes enormously complicated and often information regarding the necessary physical constants which are empirical in nature is lacking. For these reasons, successful designs have been achieved by somewhat of a trial-and-error process, although future research should point the way to rational design procedures.

SUMMARY

The advantages of the semiclosed pipe system over the open system for many irrigation water pipe distribution systems is discussed. The semiclosed system is achieved by substituting float-valve stands for overflow stands. Characteristics of the float valves are discussed; notes on the mechanics of float valves, useful in design, are included; and tests to establish the capacities of several commercial valves, heretofore lacking, are reported.

REFERENCES

1 Pillsbury, Arthur F.: Float valves for concrete irrigation pipe lines. *Calif. Citrograph* 31 : 111, 128-130 (February, 1946).

2 Pillsbury, Arthur F.: What type concrete pipe irrigation distribution systems? *Western Construction*, vol. 25, no. 9, pp. 90-92 (September, 1950).

3 Stanley, F. W.: The use of concrete pipe in irrigation. USDA Bulletin, 906 (1921).

4 Curtis, Howard G.: The Bureau of Reclamation and concrete pipe. Official proceedings, 1st annual convention, Amer. Concrete Agr. Pipe Assn., pp. 5-20 (1951).

5 Pillsbury, Arthur F.: Improvement in design and installation of plain concrete pipe irrigation systems. Official proceedings 1st annual convention, Amer. Concrete Agr. Pipe Assn. (1951).

Farm Tractor Tires

(Continued from page 395)

5 Comparative Tractor Tire Tests. SAE Transactions, vol. 33, p. 13.

6 Sauve, E. C. and McKibben, E. G. Studies on Use of Liquid in Tractor Tires. Michigan Agric. Exp. Sta. Quarterly Bulletin, vol. 27, August, 1944.

7 Sauve, E. C., and McKibben, E. G. Studies on use of Liquid in Tractor Tires, Michigan Agri. Exp. Sta. Quarterly Bulletin, vol. 28, August, 1945.

8 Shields, J. W. Pneumatic Tires for Agricultural Tractors. AGRICULTURAL ENGINEERING, vol. 12, February, 1933.

9 Smith, C. W. and Hurlbut, H. W. Comparative Study of Pneumatic Tires and Steel Wheels on Farm Tractors. Bulletin No. 291, Nebraska Agric. Exp. Sta., September 1934.

Irrigation in Relation to Food Production

J. E. Christiansen
MEMBER ASAE

THE purpose of this paper is threefold; to briefly review the development of irrigation in the United States and the world, to discuss the food problem from the world standpoint, and to determine to what extent, and how, irrigation contributes to the food supply.

Much has been said on all phases of this subject. Time has not permitted a review of more than a small part of the literature available. I have no new information, but have attempted to review some of the material available, and from it to draw some general conclusions representing the point of view of men much better qualified to speak on this subject. I will quote rather freely from some of the papers cited in order to bring out more specifically the intent of the authors.

DEVELOPMENT OF IRRIGATION

Irrigation is old. There are many biblical references to irrigation and reclamation. Quoting from O. W. Israelsen (1)*:

"Irrigation had been established when the writing of history began. The British Society of Anthropology accepts as a fundamental doctrine that historically civilization followed the development of irrigation.

"An ancient Assyrian queen, supposed to have lived more than 2,000 years B.C., is credited with directing her government to divert the waters of the Nile to irrigate the desert lands of Egypt. The inscription on her tomb is: 'I constrained the mighty river to flow according to my will and led its waters to fertilize lands that had before been barren and without inhabitants.'"

Irrigation in China is known to be more than 4,000 years old. The famous Tu-Kiang Dam, still a successful dam today, was built by Mr. Li and his son in the China Dynasty, 200 B.C., and provides irrigation water for about one-half million acres of rice fields. The Grand Canal, 700 miles long, was built by the Sni empire, A.D. 589-618 (1). China is still struggling with its reclamation problems, and a gigantic project on the Yangtze River was recently under consideration. According to available information, China leads the world in irrigated lands, with an estimated irrigated area of 90 million acres (2).

India and Pakistan rank second and third in the world in area irrigated. According to Malhotra and Ahuja (3) there are now nearly 50,000,000 acres irrigated in India, and an additional 30,000,000 acres in Pakistan. United States ranks fourth with over 26,000,000 acres according to 1950 preliminary census figures. Irrigation is also old in India. Quoting from Malhotra and Ahuja:

"ANCIENT IRRIGATION—As already stated the practice of irrigation in India can be traced back to time immemorial and mention regarding this appears in records from antiquity. In fact the irrigation practice must have originated with the earliest influx of Aryans into India from the north, when those high-spirited, enterprising and intellectual people, settled down in the rich fertile plains of India where water for growing crops was available. The engineering of dams and canals was known in India long before the dawn of history. Magasthenes, the Greek ambassador of Sleukos Nikator at the court of Sendro Kothos near Patna, writing 300 years before Christ, states that the whole country was under irrigation and prosperous, growing double crops. Some of the reservoirs in southern India belong to the same time, and are as old as 2,000 years. The Grand Anicut of Madras was built by the Chola Kings about 200 A.D. which was a remarkable work, Irrigating about 600,000 acres even before the improvements effected in the nineteenth century. The large dams of Bhopal, with its 250 square miles of reservoir area, was built by Raja Bhoj in the eleventh century A.D. *In fact the development of irrigation works from the earliest times was due to the necessity for securing the crops against failure by some form of artificial irrigation.* With the increase of population and breaking of new lands for its sustenance, the irrigation works have developed and the history of India is full of attempts by successive generations to use more and more water from rivers and artificial tanks for agriculture."

Modern irrigation work began in India with the repairing of the Western Yamuna Canal by the British in 1821, at which time it was irrigating some 20,000 acres. As a result of continued remodelings and extensions, this canal now irrigates more than 400,000 acres. The second important work was on the Canvery Delta Canal, beginning in 1834. The Upper Ganga Canal, commenced in 1836 and completed in 1862, is one of the largest works in India constructed in the nineteenth century. The following quotation is of interest:

"*This project was mooted as early as 1827, but could not mature until the terrible famine of 1836-37 and its train of calamities spurred the need for its early execution* (3)."

This is an address delivered before a special meeting of the American Society of Agricultural Engineers held in conjunction with the Centennial of Engineering Convocation at Chicago, Illinois, September, 1952.

The author — J. E. CHRISTIANSEN — is dean of the school of engineering and technology, Utah State Agricultural College.

*Numbers in parentheses refer to the appended references.

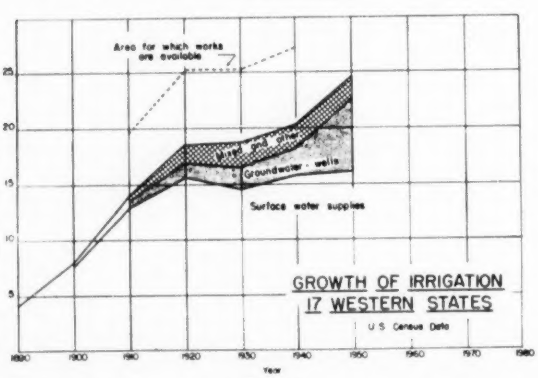


Fig. 1

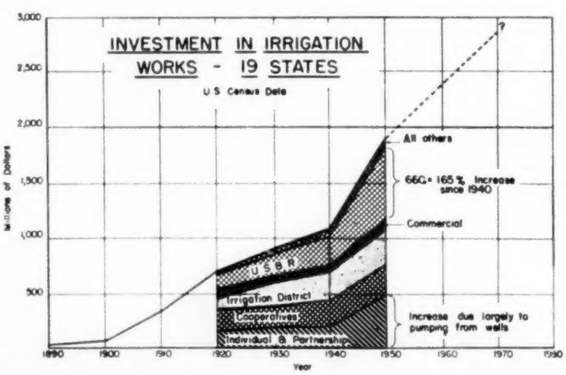


Fig. 2

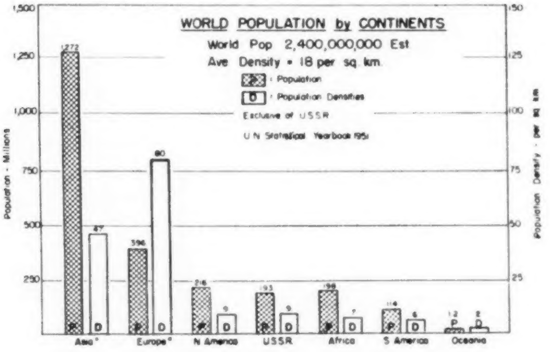


Fig. 3

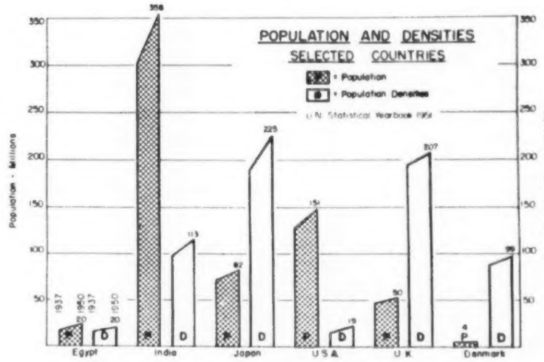


Fig. 4

The irrigation development in India has been executed almost entirely by the government. Malhotra and Ahuja (3) state:

"The experiment of entrusting irrigation works to private companies was a failure and both the Madras and East Indian Companies had to be wound up soon after inauguration and their assets purchased by the government. The failure of the private enterprise in irrigation works led to the acceptance by the Secretary of State in 1866 of the policy of supplementing the ordinary resources of the government by means of public loans for the productive irrigation works, and the adoption of this policy has led to the enormous development of canal irrigation in India since then."

IRRIGATION IN THE UNITED STATES

Irrigation in America is also old, having been practiced by the Indians at the time of the Spanish Invasion (4). There are evidences that extensive irrigation works once existed in Arizona and New Mexico. It is believed that some of these canals were built about 700 A.D. (5). Most of these earlier irrigation systems had fallen in disuse before white men came to this continent, but many of the Indians of the Southwest were still practicing irrigation on a smaller scale.

Irrigation was also practiced by the Spanish padres at the early missions in California, but to only a limited extent for gardens, orchards, vineyards, and some small grains. Irrigation was also practiced by trappers, miners, and frontiersmen in many places in the West although no effort was made to develop an agricultural economy based on irrigation until the Mormon pioneers entered Salt Lake Valley in July of 1847 (6). This was the beginning of modern irrigation in America. From the first, irrigation was a cooperative undertaking, with communities being located upon the streams issuing from the mountains. Community ditches were constructed to serve both the outlying agricultural areas, and the garden plots in the towns.

The second important irrigation development was the establishment of the Union Colony at Greeley, Colo., in 1870 (6). This community effort resulted in more than 30,000 acres being brought under irrigation.

From these beginnings, irrigation agriculture spread rapidly throughout the western states, and by 1890 the first irrigation census showed a total irrigated area of 3,631,000 acres. This area was doubled approximately during the next decade, and doubled again by 1910. The increase in irrigated area was rapid and steady up to 1920, and was mostly from surface water supplies. During the next decade there was only a very small additional acreage irrigated, mostly from ground-water supplies. A relatively small increase occurred between 1930 and 1940, and a larger gain was made between 1940 and 1950, almost entirely from ground water development. The growth of irrigation in the United States is shown graphically in Fig. 1.

The present status of irrigation development for the twelve western states with greatest irrigated acreage, according to preliminary 1950 census figures (7), is given in Table 1. Although the total acreage increased from 1939 to 1949 by approximately five million acres, it is interesting to note that five of the western states showed a decrease in acreage for this same period. The greatest increase was in Texas, from 1,045,224 to 3,148,115 acres, a gain of more than 200 percent. This increase occurred chiefly in the High Plains area where practically all of the irrigation water comes from pumped wells. It is believed that this area has overdeveloped its ground-water supply (8), and that this acreage may decrease, rather than increase, during the next decade. The second largest gain was in California where the area increased from 5,069,568 to 6,618,595 acres. Ground-water development in San Joaquin Valley accounted for most of this increase. The Central Valley Project of the USBR (U.S. Bureau of Reclamation) will probably make possible a further increase in this area and sustain the increased draft on the underground water supply.

TABLE 1. IRRIGATED ACREAGE AND CAPITAL INVESTMENT

State	Irrigated land (thousands of acres)		Percent change	Capital investment (millions of dollars)		Capital investment (per acre irrigated)	
	1939	1919		1940	1950	1940	1950
California	5,070	6,619	+30.5	318.9	640.1	$62.90	$96.71
Texas	1,045	3,148	+201.2	66.4	144.5	63.54	45.90
Colorado	3,221	2,941	−8.7	106.8	161.4	33.16	54.88
Idaho	2,278	2,168	−4.8	102.6	130.0	45.04	59.96
Montana	1,711	1,810	+5.8	67.4	82.0	39.39	45.30
Wyoming	1,486	1,475	−0.7	41.5	59.6	27.92	40.41
Oregon	1,049	1,338	+27.6	51.0	74.4	48.62	55.61
Utah	1,176	1,166	−0.9	41.9	56.6	35.62	48.54
Arizona	653	979	+49.9	83.5	137.6	127.87	140.55
Nebraska	610	888	+45.6	39.1	56.5	64.10	63.63
Nevada	740	723	−2.3	16.9	20.2	22.84	27.94
New Mexico	554	691	+24.7	32.7	61.6	59.03	89.15
17 western states	20,395	24,869	+21.9	1,034.7	1,831.4	50.73	73.64
U.S. total	21,136	26,148	+23.7	1,059.1	1,887.1	50.11	72.17

Considerable increase in irrigated area has also taken place in Arizona, New Mexico, Nebraska, Louisiana, and Florida. The total for the last three mentioned states increased from 741,058 to 1,379,609 acres, or 86.1 percent.

As will be noted from Table 1, the capital investment in irrigation works increased from $1,059,100,000 to $1,887,100,000, or 78.2 percent. The present investment in irrigation works, however, is less than was spent during World War II for the atomic bomb development, and only a small fraction of the annual cost of the "cold war." The capital investment per acre irrigated increased during the period from 1940 to 1950 in all of the states except Texas.

Fig. 2 shows the growth in investment in irrigation works by types of enterprise. Up to 1920, this investment was largely by private enterprise, cooperatives, and irrigation districts. Since then there has been a much larger increase by federal participation through the USBR, and by underground water development by individuals.

Data available on a world basis likewise show a very striking increase in irrigated area during the past half century. In India and Pakistan, the total area has increased from about 30 to 80 million acres since 1892 (2). The present acreage irrigated in various countries of the world, according to latest available information, is given in Table 2.

TABLE 2. IRRIGATED LANDS OF THE WORLD*

Country	Estimated irrigated area (1000 acres)	Principal crops grown
China	90,000	Rice, wheat, millet, vegetables
India	48,921†	Rice, cotton, grains, fruit, vegetables
Pakistan	30,000†	Rice, cotton, grains, fruit, vegetables
United States	26,248‡	Forage crops, sugar beets, potatoes fruits, vegetables
Indo-China	12,000	Rice
Japan	9,450	Rice, cereals, potatoes
Java	8,500	Rice
Russia	8,000	Cereals, cotton, fruit
Mexico	7,500	Cotton, fruit, vegetables
Egypt	6,250	Cotton, cereals, vegetables
Italy	4,500	Rice, cereals, forage crops
Spain	3,500	Cereals, forage crops, fruit, vegetables
Argentina	3,200	Cereals, forage crops, cotton, corn
France	3,150	Cereals, potatoes, vegetables
Chile	3,000	Cereals, fruit, vegetables
Iran	2,500	Rice, grain, cotton, tobacco

*Except as otherwise noted: D. W. Thorne and H. B. Peterson, Irrigated Soils, Their Nature and Management, 1949 (2).

†S. L. Malhotra and P. R. Ahuja, Review of Irrigation Development and Practice in India, 1951 (3).

‡U.S. Census, Preliminary Report on Irrigation, 1952 (7).

Thorne and Peterson point out that there are highly variable estimates of irrigated land in some of the countries, especially for the Asiatic countries.

FUTURE EXPANSION OF IRRIGATION

There will certainly be further development of irrigation in the United States, and there is reason to believe that there will be a similar increase in irrigated area in many other countries. Canada, Chile, India, Pakistan, South Africa, and Australia have sizeable projects in the planning or construction stage. The cost of developing new irrigated areas, however, is increasing rapidly. The areas readily accessible to available water supplies have long since been developed. New areas are farther from supplies, will require extensive storage facilities, and in some instances long tunnels for transmountain diversions.

The U.S. Bureau of Reclamation's proposed program (9) as outlined in 1948, called for the construction of works that would irrigate by 1954, 2,040,000 acres of new land, and would supply supplemental water for an additional 3,610,000 acres. This program has been slowed down, however, as a result of the Korean War and increased federal expenditures for defense. The Bureau's report indicates that water is available for an additional 14,800,000 acres that might be developed in the future. These developments will be expensive, and will require high dams, long tunnels, canals and pipe lines, including huge hydroelectric developments. They will be multipurpose projects involving irrigation, hydroelectric power, flood control, municipal water supplies, fish and wildlife conservation, and recreation. Some of the long-range thinking and planning being done, is evidenced by an article in *Time* (10) which points out possibilities of exporting some 6,000,000 acre-feet of water from the Klamath River watershed in northern California, into the Sacramento-San Joaquin basin with canals and tunnels carrying it the length of the Central Valley and through the Tehachapi Mountains into southern California and as far south as San Diego. This development is estimated to cost more than three billion dollars—almost twice the total investment in irrigation works in 1950. This project could add about 2,000,000 acres of new irrigated land.

WORLD FOOD PROBLEM

Much has been written and said on the world food problem. Lord John Boyd-Orr, former director-general of the United Nations Food and Agricultural Organization, writing in the *Scientific American*, August, 1950 (11) says:

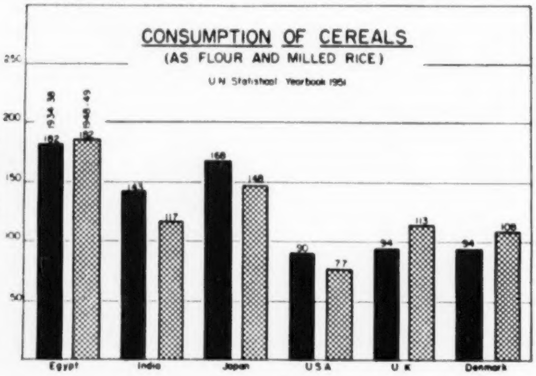


Fig. 5

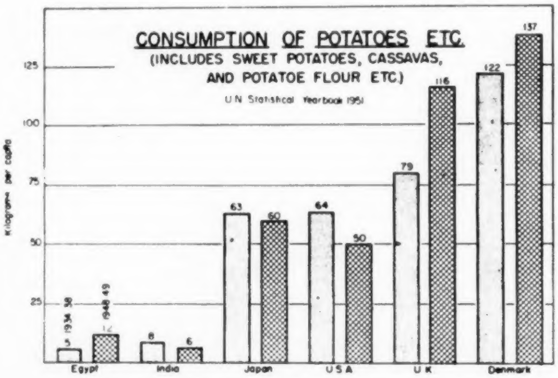


Fig. 6

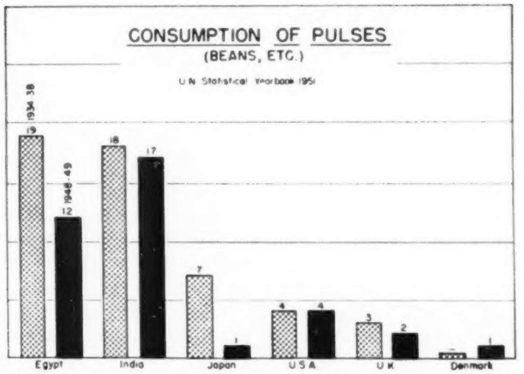


Fig. 7

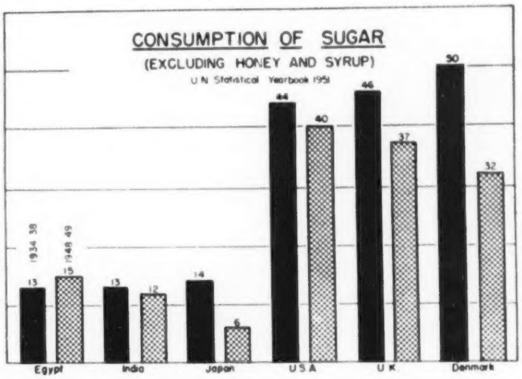


Fig. 8

"The food problem confronts the world with two dangers. One is the political danger of hunger. A lifetime of malnutrition and actual hunger is the lot of at least two-thirds of mankind. Hungry people who believe that an abundant supply of food is possible will overthrow any government that does not make it available. The upsurge in Asia, the most important political event in the world today, is fundamentally a revolt against hunger and poverty.

"Side by side with the political menace of hunger, there exists in the now small world an economic danger, arising from diametrically opposite causes. This economic difficulty is due to the ease with which food can be provided with the help of modern technology. Certain countries, the United States and Canada in particular, are embarrassed by surpluses of food.

"The gravity of the food problem is such that some observers have arrived at the hopeless conclusion that the nineteenth century English economist, Thomas Malthus, was right, that is, that population tends to increase faster than the supply of food, and that part of the population inevitably has less food than it needs. Certainly the population of the world is increasing at an accelerating rate. At the beginning of the nineteenth century, it was estimated at a little over 900 million. At the outbreak of World War II it had reached about 2 billion, and is now about 2.25 billion and is increasing at a rate of more than one percent, or about 22 million per year. At this rate it will reach between 3 and 4 billion during the lifetime of our children.

"If the kind of effort being made by the World Health Organization succeeds in eliminating preventable diseases, the rate of increase in population will be much greater than one percent. The life expectancy at birth of half of the population of the world is only 30 to 40 years compared with 65 or 70 years in countries where modern preventive medicine has been applied."

According to Lord Boyd-Orr, the food production of the world could be greatly increased. He says:

"It is claimed that the land presently under cultivation could support twice the present world population if it were made to yield to the full capacity possible by modern technology. The most frequently cited example of overpopulation is India, with 'its three mouths to two rice bowls' and its population increase of 4 million a year. Yet the task of doubling the food output of India has now been thoroughly investigated; the means are at hand, the engineering program to this end is already underway. At present the Indian yield per acre of rice and wheat is little more than a third of that in Japan. This is because the land is starved for humus, fertilizers, and water. The humus and fertilizers can be provided, and plenty of water falls on the land. *India is lacking only in storage and irrigation facilities to use the rainfall to the best advantage.* This can be remedied. The new government of India has embarked on a great plan of agricultural development which will go hand in hand with the complimentary industrial program. If the industrial program could be carried to completion in time, the food supply could be doubled in ten or fifteen years."

Lord Boyd-Orr believes that the solution to the world food problem is through international effort. He says:

"The two evils of the glut of food in the United States and hunger in widespread areas in the rest of the world cannot be eliminated by United States' charity. It can be met only by international effort. Conducted through the technical agencies of the United Nations, the world food problem would be placed upon a business footing and bring as much benefit to the United States as to other countries. Only by multilateral action can the United Nations redeem the forgotten pledge of the Atlantic Charter to achieve 'freedom from want among the people of all lands.' "

A somewhat similar point of view is taken by Dr. J. H. Richter, head, European division, regional investigations branch, OFAR. In speaking before the Western Farm Economic Association (12), he says:

"My contention is that the present world food situation calls for larger, not smaller, production of the basic foodstuffs and feedstuffs; and I shall argue that market developments in prospect are unlikely to prove an impediment to such an aim.

"Population is increasing in all parts of the world. Where food consumption is low, in quality as well as in quantity, improvement must mostly come from increases in domestic output. In Europe, similarly, improvements in food consumption depend largely on the countries' capacity to produce more themselves; in addition, large food and feed imports will continue to be required. . . ."

On the position of the United States, he continues:

"Turning to more specific factors that should influence the markets for the basic foodstuffs and feedstuffs, I venture to count the preponderant position that the United States has acquired as an exporter of grains and fats and oils since World War II. It is well realized that, if a substantial share of world exports is supplied by one single source, the effects of crop failure in that particular area would be drastic indeed. This knowledge of vulnerability of world export supplies is, of course, a factor in the market situation.

"In the past two consumption years, 1948-49 and 1949-50, the United States supplied fully 45 percent of total world shipments of wheat, 35 percent of total world shipments of coarse grains, and 15 percent of total world shipments of fats and oils. This represents a very great expansion compared with the 1930's or even the 1920's, when American exports of grains were sharply on the decline and when the United States was a net importer, not a net exporter of fats and oils. . . ."

He adds:

"Quite generally it should be noted that, as Professor DeGraff has pointed out, the great increase in United States food output from the late 1930's up to 1944 was to a considerable extent due to exceptional circumstances, not likely to be repeated. It was out of this increase that the United States supplied so much to the rest of the world. For the past 6 years, total food production in this country has hardly exceeded the level attained in 1944. The margin between output and domestic needs for the growing population has thus declined, and so have food exports over the past 2 or 3 years. The United States cannot, therefore, expect, and the rest of the world cannot count on, a permanent United States export of current magnitude. . . ."

Wesley R. Nelson, formerly assistant commissioner, U.S. Bureau of Reclamation, has stated (13):

"The human population of this planet is growing by leaps and bounds. The increase is about 70,000 per day.

"The amount of land under cultivation in the world stopped growing some time ago. In fact, during the decade 1940 to 1950, cultivated acreage decreased by about 3 percent. During the same period, despite great wars and natural disaster, world population increased by some 200,000,000."

The comparative populations and population densities of the continents of the world are shown in Fig 3, which has been prepared from data taken from the United Nations Statistical Yearbook, 1951 (14). One interesting point brought out by this figure, is the similarity in total population and population density of the USSR and the continent of North America. The comparatively large population of Asia, and the high population densities of both Asia and Europe are also emphasized.

Fig. 4 gives similar data for a few selected countries, and brings out the extreme contrasts in various parts of the world.

To better understand the real nature of the world food problem, a detailed analysis of the food consumption, and the comparative birth and death rates in these same countries has been made. These data are shown graphically in Figs. 5 to 12, which emphasize the relatively poor diets of the people in many of the populated countries of the world, as contrasted with the United States, the United Kingdom, and Denmark. Similar data were not available for China, and certain other countries where the food problem is acute.

The diet of a large segment of the world population is made up of cereals (largely wheat and rice), beans, and in some instances, potatoes or other root crops. These diets are deficient in sugar, meat, milk and dairy products, and fats and oils. Only a small percentage of the caloric content is derived from animal sources as is shown in Fig. 12.

There appears to be no relation between these relatively poor diets, the food shortage in general, and the birth rates for these countries. All of these countries have substantially higher birth rates than countries with adequate diets, but they also have higher death rates, and shorter life expectancies. Generally there was an increase in birth rates following the war with a subsequent decrease and some reduction in death rates during the past few years, probably due to an improvement in medical and health services since the war. One might speculate as to what modern medical and health programs with increased use of some of the recently developed antibiotics could do to the populations and food supplies of some of these countries where present death rates are now twice that of the United States.

FOOD PROBLEMS IN THE UNITED STATES

The food problem in the United States and its relation to irrigation and reclamation was discussed recently by Dr. Byron T. Shaw, administrator of the Agricultural Research Administration, USDA, before the House Subcommittee on Agricultural Appropriations (15). Although, as has already been pointed out, our principal food problem has been economic, resulting from food surpluses, this is not likely to continue for many years. Dr. Shaw points out that with the population increase expected, there will be 190 million people by 1975. Our total agricultural cropland has remained essentially static since 1920, although the farm output index has increased from 92 in 1920 to 138 in 1950 (1935-39 average = 100). Most of this increase in production had occurred by 1946, and there has been little change since then. Since 1935 the equivalent of about 45 million acres of cropland has been released from feeding horses and mules. By 1975, another 15 million acres can be expected to be released from this use. Based on the President's Water Resources Committee report, Dr. Shaw estimates that about 30 million acres can be added to our cultivated area by reclamation through irrigation, drainage, and land clearing. Of this, about 6 million acres could be brought into production by 1975 through irrigation. This, however, is more than the total area brought under irrigation by the U.S. Bureau of Reclamation in its first fifty years of existence, and will not be an easy goal to meet.

Dr. Shaw says that in order to maintain the 1950 standard of diet, we would need about 577 million acres equivalent of cropland by 1975, or about 70 million acres more than appears to be available, according to the most optimistic estimates. To provide an adequate diet for all, would require an additional 112 million acres, or a total of 689 million acres. This indicates that we are certainly much closer to the day when we will actually face a food shortage in the United States than most of us realize. Considering the time required, and the expense involved in bringing new land into production under irrigation, it is evident that a reclamation program on an adequate scale should be maintained. It is pointed out (15) that from the beginning of construction of the Grand Coulee Dam in 1933 to the completion of facilities to irrigate the first half million acres by 1958 is 25 years, and that the time to completion of the project in 1971 to irrigate the remainder of the project, an additional 529,000 acres, will be an additional 13 years. There is now no other single project under construction or investigation that can add as much new irrigated land as the Columbia Basin project. The total area for ultimate development in the Missouri Basin as now planned is 5.3 million

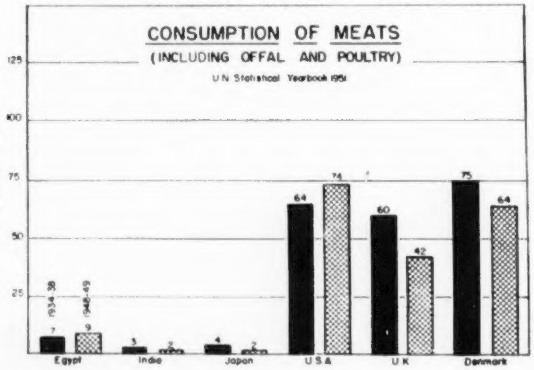


Fig. 9

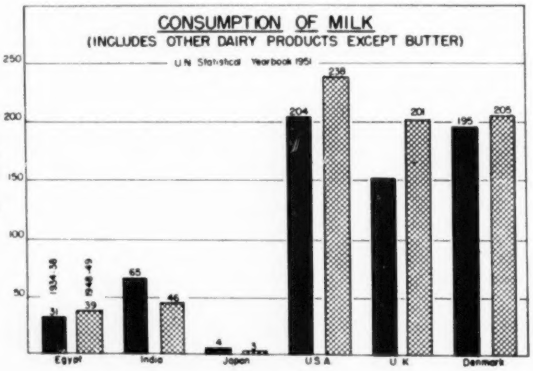
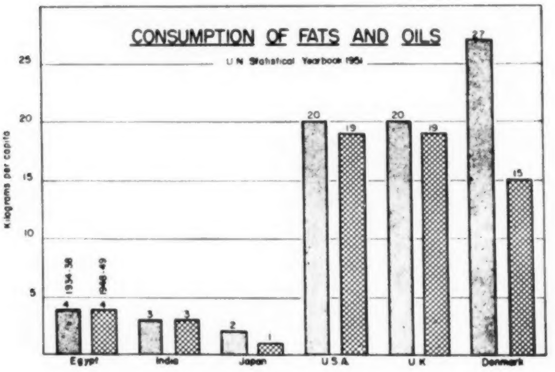


Fig. 10



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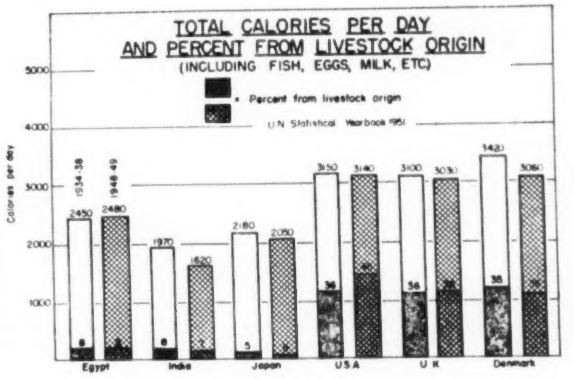

Fig. 12

acres. This, however, will come largely from land now cropped in seven states, (9).

Lewis A. Jones, in a recent meeting of the ASAE, called our attention to the changing picture of our own food problem (16). Where until recently one of our chief concerns was food surpluses, we now face the task of increasing our production. He says:

"As a result of these heavy demands, the agricultural surpluses we heard so much about a few years ago are now a myth. The supplies of such items as butter, cheese, dried milk, canned vegetables, and canned fruit held by the Commodity Credit Corporation have been reduced fifty percent since the start of the Korean War, and are continuing to decline at a rapid rate. . . . The corn carry-over for 1952 is estimated at 635 million bushels, or about 20 percent of the annual requirement. . . .

"The wheat carry-over for 1952 is estimated at 375 million bushels instead of the 500 million bushels considered desirable in case of a bad crop year or for abnormal export in case of famine or crop failure in other wheat-exporting countries. At this very moment we are losing ground; we are consuming at a greater rate than we produced in 1950, and it appears that demands in 1952 will exceed our 1951 production.

"To win the battle we will need every ounce of production we can squeeze out. High-level production is the greatest contribution agriculture can make to price stability."

Following this same line of reasoning, Jacob Rosin, in a recent article in *Readers Digest* (18), argues that the road to abundance lies in the manufacture of synthetic foods, utilizing, as one of the basic raw materials, the carbon dioxide of the atmosphere. He says:

"The only question is: How long before we shall get going under full steam down this road to survival, which also is the road to abundance? All we have to do is 'shake up' our mental habits, and realize that the chemical industries, sufficiently subsidized, can do the same thing the plants are doing, and do it a thousand times more efficiently and cheaply. And why not do it before we are faced with starvation?"

Until the time comes when this is possible, we must concern ourselves with agricultural production, and look forward to the job of keeping production abreast of demand. When the time comes for the manufacture of synthetic foods, I dare say that agricultural engineers will play a leading role in this new development.

IRRIGATION AGRICULTURE'S CONTRIBUTION TO FOOD SUPPLY

The irrigated lands in some of the countries of the world, especially the Asiatic countries, provide an appreciable portion of the supply of such basic foods as cereals and rice, their basic diets. In India, approximately 25 percent of the total cropped area is irrigated (3), and a larger portion of the food supply comes from the irrigated land because of higher yields. For the United States (7) there was a total of 344 million acres of cropland harvested in 1949, a decrease of 8.5 million from 1944. There has been no significant change in this area since 1919 when 349 million acres were reported (15). The irrigated area now represents only 7.5 percent of this total, and supplies a very small percent of such basic foods as wheat and corn as shown by Table 3. It does, however, contribute substantially to many of our other foods such as vegetables, fruits, and nuts. Inasmuch as census data on production from irrigated lands are not yet available for 1950, similar data were obtained from Agricultural Statistics, 1951 (19).

TABLE 3. PRODUCTION OF BASIC FOODS ON IRRIGATED LANDS IN U.S.—1939 (17)

Crop	Production	Percent of U.S. Production
Corn, for grain	1,354,000 bu	0.6
Wheat, winter	8,209,000 bu	1.5
Wheat, spring	11,633,000 bu	7.0
Potatoes, Irish	79,502,177 bu	25.0
Beans, dry	10,420,000 bu	44.0
Sugar beets	8,170,000 tons	79.5
Rice	43,687,000 bu	99.5

TABLE 4. PRODUCTION OF COMMERCIAL VEGETABLES IN ELEVEN WESTERN STATES AND TEXAS, 1949*

Crop	Production	Dollar value	Percent of U.S. Production	Percent of U.S. Value
Artichokes	674,000 boxes	$ 2,730,000	100	100
Asparagus	101,595 tons	17,320,000	60	52
Beans, snap				
Fresh	2,268,000 bu	5,183,000	13	14
Processed	92,900 tons	10,832,000	38	39
Cantaloupes	9,636,000 crates	27,443,000	78	81
Carrots	19,677,000 bu	33,136,000	78	86
Cauliflower	8,539,000 crates	10,001,000	65	64
Celery	14,541,000 crates	26,464,000	64	52
Garlic	131,000 sacks	1,305,000	93	94
Honey dew melons	2,615,000 crates	4,730,000	100	100
Lettuce	31,431,000 crates	117,468,000	93	94
Onions, dry	35,271,000 sacks	44,730,000	93	80
Peas, green				
Fresh	2,766,000 bu	5,870,000	91	91
Processed	119,860 tons	10,583,000	34	35
Potatoes, early	32,186,000 bu	44,389,000	49	46
Potatoes, total	134,833,000 bu	177,760,000	33	34
Spinach, fresh	6,115,000 crates	6,984,000	49	60
Processed	53,200 tons	1,430,000	56	35
Tomatoes, fresh	12,347,000 bu	33,019,000	39	35
Processed	1,149,000 tons	26,440,000	46	44
Watermelons	28,115,000 melons	7,359,000	36	30
Truck crops				
Commercial	6,194,100 tons	364,644,000	45	46

*Agricultural Statistics, 1951, U.S.D.A. From tables 282 to 344.

TABLE 5. PRODUCTION OF VEGETABLES, FROZEN, COMMERCIAL PACK IN EIGHT WESTERN STATES—1949*

Crop	West† (1000 lb)	Total U.S. (1000 lb)	Percent of U.S.
Asparagus	12,890	22,309	58
Beans, snap	22,271	65,529	34
Beans, lima	46,690	85,988	54
Broccoli	30,246	41,028	74
Brussel sprouts	22,439	22,439	100
Carrots	7,684	13,338	57
Cauliflower	8,420	12,339	68
Corn, cut	13,866	32,998	42
Corn, on cob	4,082	10,069	38
Peas	102,183	152,275	67
Peas and carrots	7,703	11,335	68
Pumpkin and squash	6,653	8,325	80
Rhubarb	4,047	6,164	66
Spinach	26,506	52,806	50
Succotash	2,329	6,659	35
Miscellaneous	9,954	43,500	23
Total	327,963	587,101	56

*Agricultural Statistics, 1951, USDA Table 350, p. 273.

†California, Colorado, Idaho, Montana, Oregon, Utah, Washington, and Wyoming.

TABLE 6. PRODUCTION OF COMMERCIAL FRUITS AND NUTS IN ELEVEN WESTERN STATES AND TEXAS—1949*

Crops	Production	Dollar value	Percent of U.S. Production	Percent of U.S. Value
FRUITS				
Apples	48,994,000 bu	$74,000,000	37	40
Apricots	197,000 tons	13,330,000	100	100
Avocados	15,500 tons	6,913,000	76	90
Cherries (sweet)	126,330 tons	19,600,000	92	92
Citrus				
Lemons	11,360,000 boxes	41,800,000	100	100
Oranges, all	44,605,000 boxes	89,635,000	43	39
Navel	16,215,000 boxes	35,907,000	100	100
Grapefruit	12,300,000 boxes	18,130,000	36	27
Dates	14,100,000 tons	2,228,000	100	100
Figs	93,860 tons	5,714,000	100	100
Grapes	2,496,200 tons	81,800,000	94	84
Olives	35,000 tons	6,650,000	100	100
Peaches	44,774,000 bu	53,200,000	60	46
Pears	30,453,000 bu	30,453,000	84	82
Plums and Prunes	626,600 tons	42,050,000	99	99
Strawberries	3,280,000 crates	20,780,000	37	33
NUTS				
Almonds	43,300 tons	14,289,000	100	100
Filberts	22,280 tons	4,782,000	100	100
Pecans	14,500 tons	5,280,000	23	22
Walnuts	88,100 tons	30,785,000	100	100

*Agricultural Statistics, 1951, USDA Tables 209-361.

Table 4 gives the production of commercial vegetables in the eleven western states and Texas in which irrigation is practiced extensively. These twelve states contribute more than 50 percent of the total production of twelve of the items listed, and 100 percent of the total production of two of them. In these states, vegetables are grown primarily on irrigated land. The West produces a substantial portion of the frozen vegetables produced in the United States as shown in Table 5. For comparison, it might be mentioned that these twelve states have 40.5 percent of the total area in farms, but only 18.1 percent of the population (20).

A similar tabulation for fruits and nuts is given in Table 6. This shows even more strikingly our dependance upon irrigation agriculture for practically all of the nation's supply of ten items listed, including dates, olives, almonds, navel oranges, walnuts, apricots, lemons, plums and prunes, and figs; and for 94 percent of the grapes, 84 percent of the pears, and 60 percent of the peaches. Other items such as nectarines, tangerines, pomegranates, persimmons, loganberries and young berries are nearly all grown in the West.

The irrigated lands also make a substantial contribution to the nations supply of livestock and livestock products. Table 7 gives the production and percentage of total for the eleven western states and Texas which are largely dependent upon irrigation for their agricultural economy. Here irrigation makes possible the efficient utilization of some 700 million acres of western range lands, which are seasonal in nature, by providing much of the feed required for winter or dry season use. Irrigated lands also produce much of the feed required for dairy and poultry production in these states.

Irrigation is rapidly becoming more extensively practiced in the humid areas of the country. Comparative figures for 1939 and 1949, including the area irrigated by sprinkler systems is shown in Table 8. It is of interest to note that in 1949 every state in the Union and the District of Columbia reported irrigated areas. The increase in the humid areas is due largely to the more extensive use of sprinklers. Unofficial estimates for 1952 indicate that more than 1,000,000 acres are now irrigated by sprinkler systems.

CONCLUSION

Summarizing, it may be said again that the world is rapidly approaching a time when food may become a limiting factor in the increase in population. Many parts of the world are now deficient in foods, and people survive on inadequate diets. Hunger is undoubtedly the greatest single cause of political revolt, and the basic underlying cause of the present problem in Asia today.

Irrigation plays a very important part in the world in the production of basic foods such as cereals, including rice. In the United States, it plays its greatest role in providing

(Continued on page 410)

TABLE 7. PRODUCTION OF LIVESTOCK AND LIVESTOCK* PRODUCTS IN ELEVEN WESTERN STATES AND TEXAS, 1949

Product	Production	Value	Percent of U.S. Production	Percent of U.S. Value
Cattle (all)	2,745,345 tons	$1,067,820,000	28	27
Hogs	558,950 tons	215,250,000	6	7
Sheep and lambs	365,379 tons	142,000,000	56	54
Wool	77,158 tons	78,800,000	72	74
Milk (total)	8,620,000 tons	755,177,000	14	17
Chickens	174,340 tons	91,087,000	13	13
Eggs	8,760 million	348,833,000	15	16
Turkeys	169,242 tons	108,959,000	43	40
Honey	34,179 tons	——	30	—

*Agricultural Statistics, 1951, USDA Tables—417.

TABLE 8. COMPARATIVE IRRIGATED ACREAGE IN 1939 AND 1949 (20)

Region	Area irrigated, acres 1939	1949 Total	1949 Percent increase	1949 By sprinklers	Percent of total
New England	2,846	31,450	1005	18,783	60
Middle Atlantic	17,260	54,616	217	42,030	77
East North Central	10,833	36,237	235	31,205	86
West North Central	636,881	1,136,018	78.5	18,302	1.6
South Atlantic	128,037	381,044	197	89,777	23.6
East South Central	891	6,950	680	1,794	25.9
W. South Central	1,472,456	4,162,837	182	46,323	1.1
Mountain	9,912,862	11,642,524	17.4	43,324	0.4
Pacific	5,800,764	8,324,169	43.5	348,449	4.2
U.S. total	17,982,830	25,775,845	43.3	639,987	2.5

Lining Irrigation Canals to Save Water and Land

C. W. Lauritzen
AFFILIATE ASAE

LINING irrigation canals is the simplest and most effective method of saving both water and land in irrigated areas. Although costly, it is likely to be cheaper than developing additional water by increased storage. At the same time it takes much of the burden from drains in areas affected by high water tables fed by seepage and deep percolation from excessive irrigation.

The need for lining is generally recognized. The chief problem is one of financing. It seems safe, however, to predict that eventually most canals will be lined. Lining of many canals is economically justified today and it is just a question of time and competition for water until the lining of many others will be justified. In view of this trend, it is important that the problem of lining be carefully investigated to determine the most effective and economic types for different geographic areas and associated site conditions.

TYPES OF LINING

Practically all construction materials have been employed as linings. Relative costs of materials and labor, together with the development of construction practices, influence the type of lining used. In the United States concrete is the most widely used material, followed by linings of earth and asphaltic materials. In other countries, such as India, a type of brick or adobe block mortared in place is widely used.

CONCRETE LINING

Among the materials used, concrete has much to recommend it for lining canals. Cost has been the chief deterrent to the use of concrete for lining. While costly, concrete linings have been and continue to be the most economical linings when installed on well-drained, stable subgrades. The initial cost of concrete linings, although higher than some other types, does not necessarily mean that the annual cost will be higher. Based on the best information available, it would seem the annual cost will be lower than that of any other material, where installed under conditions favorable to the use of concrete and in areas where a satisfactory concrete aggregate is available locally. Among the factors which contribute to the favorable position of concrete for canal linings are (1) long-service expectancy, (2) low maintenance costs, (3) smaller cross sectional requirements compared to some other types, (4) higher permissible velocities than some other types, (5) good resistance to mechanical damage and ease with which repairs are made, (6) minimum requirements for cleaning and water weed control, and (7) effectiveness as a ditch-bank weed-control measure.

The advantages of concrete as a lining material are most pronounced when considered in connection with new construction because of the lesser right-of-way requirement and the smaller amount of excavation necessary for the construction of the canal. Where old canals are to be lined with concrete, a common practice is to backfill the old canal with compacted materials and re-excavate to provide the smaller cross section required. Because of this, where a heavy growth of trees and brush has developed along the old canal, it is often cheaper to relocate the canal than to prepare the old canal for lining. The comparatively small cost of relocation as compared to lining makes it highly desirable that plans developed preparatory to lining provide for relocating all sections of canal which would improve operation or reduce the length. Reducing the length can be an important factor in reduced lining cost and does away with maintenance and seepage problems to that extent forever.

Since conditions vary from canal to canal, plans for the installation of concrete linings in old canals should include some trial computation to determine the most efficient section from the standpoint of existing conditions. This may vary in both shape and lined area from the most efficient section hydraulically. Where the cost of backfilling and re-excavation is high, it may be desirable to design the linings with much wider base and steeper side slopes to conform to the shape of the existing canal. Normally this will necessitate forming the sidewalls and the use of some steel reinforcing, although it is possible that slip forms could be developed for doing the job.

The most siginficant advancement in canal lining has come from the increased mechanization entering into the construction of concrete linings. Advances in mechanization are continuing and the future looks bright for even lower cost construction in spite of mounting costs for labor and material. Cost can vary widely from job to job, and while figures for government jobs may not be representative of private jobs, they illustrate the trend. The effect of this development on cost is indicated by data taken from U.S. Bureau of Reclamation records*. Commenting on these data, the Bureau of Reclamation states that while 3 to 4-in reinforced concrete lining cost about \$3 per sq yd in 1946, unreinforced linings of the same thickness averaged about \$2.20 in 1949 and 1950. Some data on the cost of concrete linings in old canals which were backfilled and re-excavated are given in Table 1. These linings were installed in

*Canal Linings and Methods of Reducing Costs, U.S. Bureau of Reclamation.

TABLE 1. COST OF CONSTRUCTING CONCRETE LININGS IN SMALL OLD UNLINED IRRIGATION CANALS

Lining	Cost per square yard Earth work	Mortar	Reinforcing	Placing	Total
Richmond Irrigation Company Canal					
3 in Reinforced					4.09
3 in Unreinforced					3.10
2 in Reinforced					2.93
2 in Unreinforced					2.45
Wilson Irrigation Company Canal					
3 in Reinforced	0.88	1.02	0.62	0.82	3.26
3 in Unreinforced	0.88	1.02		0.72	2.62
2 in Reinforced	0.88	0.62	0.41	0.79	2.70
2 in Unreinforced	0.88	0.62		0.75	2.25
Yellowstone Feeder Canal					
3 in Unreinforced	1 85	1.98		1.22	5.05

This paper was presented at a meeting of the Rocky Mountain Section of the American Society of Agricultural Engineers at Laramie, Wyoming, April, 1953. It is a contribution of the Soil Conservation Service, USDA, in cooperation with the Utah Agricultural Experiment Station.

The author — C. W. LAURITZEN — is project supervisor, division of irrigation engineering and water conservation, Soil Conservation Service, U.S. Department of Agriculture.

10-ft alternate panels, largely with farm labor. As an example of what can be done, a 3-in concrete lining, base 0.75 ft, depth 1.4 ft, and side slopes 1.1 was installed with a slip form at a cost of $1.00 per linear foot or $1.58 per sq yd. The cost of $1.58 includes excavation of the channel and preparation of the subgrade. This was the first job for the contractor and the deviation from line and grade was greater than desirable, but with a little experience deviations could be kept well within recommended tolerances at no extra cost.

EARTH LININGS

Lining with earth materials has been practiced with varying degress of success since the time the first canals were built. Of all linings, earth linings can be constructed at the lowest cost where suitable lining material is available close at hand. This condition necessarily greatly limits the locations where earth linings can be justified.

Two types of earth linings are generally recognized, thin 6 to 12-in blankets and compacted earth linings about 3 ft thick. Both types, in order to be durable, must be covered with a layer of non-erosive material such as gravel or shale. The cover serves as a protection against both erosion from stream velocity and wave action and deterioration from cracks caused by drying. Where a heavy layer of cover is used it discourages the establishment of vegetation to some extent and provides some demarkation between the lining and silt deposits, which is helpful in canals where these deposits occur and must be removed from time to time. Both types of earth linings are restricted to canals with velocities of about 3 fps or velocities below the limiting velocity for the cover material.

The permeability of earth materials varies widely and it is evident that lining a gravel subgrade with sand would reduce seepage losses. On the other hand, it is considered good judgment to limit the use of earth materials to those materials which will provide relatively watertight linings. Materials for earth blankets, it appears, should be confined to those earth materials which have a low permeability independent of compaction, such as soil bentonite mixtures and certain soil materials. Thick rolled earth materials, particularly where they are to be used without a protective cover, will be more durable if a material having a texture range around a sandy clay is used. Texture alone, however, is a poor criteria of permeability and the probable effectiveness of earth materials for lining.

The effectiveness and cost of earth lining probably vary more widely than any of the other types. Some cost data may nevertheless be of interest. The Bureau of Reclamation reports the installation cost of a 12-in compacted earth lining as low as 17c per sq yd and heavy compacted earth linings as low as 42c. Probably more representative figures would be 50c and $1.00. Israelsen† cites a cost of 42c per sq yd for a 4-in lining of oasis clay covered by about 1 in of gravel.

ASPHALT LININGS

Asphalt is not new in the field of canal lining. It has been employed in many forms involving varied construction practices. At the present time its use is limited largely to two types of lining, asphaltic concrete and buried asphaltic membrane lining. The concrete consists of sand and gravel aggregate held together with an asphalt binder. The material is hot mixed and placed while hot. It has much the same property as concrete hydraulically and construction costs are about the same. It is subject to damage by vegetation penetration, and therefore subgrades except in sterile material must be sterilized. Few data are available on the probable life of asphaltic concrete linings, but it has properties in its favor and its value for canal lining should be the subject of continued investigation. Most needed is better information on the probable life of linings constructed of the material and on maintenance requirements.

Buried asphaltic membrane linings are a recent development. Apparently they are the outgrowth of earlier attempts to develop a satisfactory exposed membrane. Recent success is hinged on the development of a type of asphalt with a high softening point and some plasticity over a wide range of temperature. The buried asphaltic membrane lining consists of an asphaltic membrane usually ranging from ⅛ to ½ in thick protected with a covering of earth material not less than 12 in deep. In some cases the membrane is sprayed on the subgrade and in others installed as a prefabricated liner similar in appearance to asphalt roofing. The first prefabricated asphaltic liner was coated on paper. Since that time liners reinforced with fiberglas, asbestos, and roofing felt have been manufactured. While all these are similar, it appears that any type of filler or reinforcing improves the durability. The sprayed type is the cheapest and most widely used, the prefabricated liners being confined largely to use in smaller canals.

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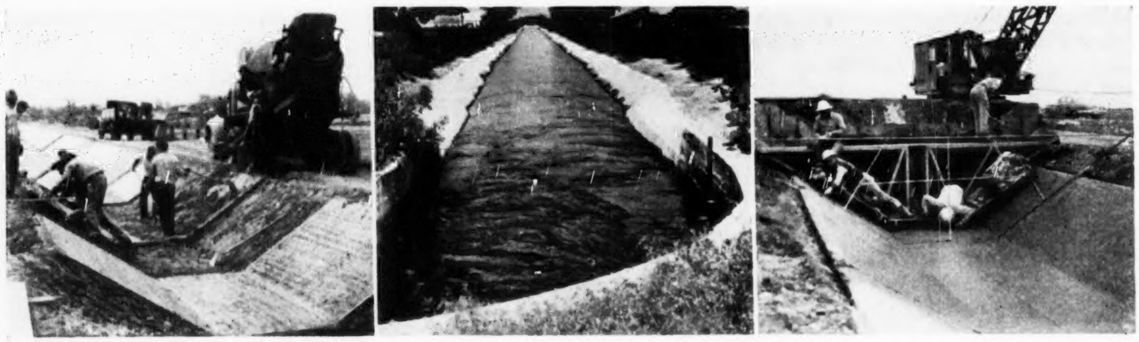
†Canal Lining Experiments in the Delta Area, Utah. O. W. Israelsen and R. C. Reeve, Utah Agricultural Experiment Station Bulletin 313.



(Left) Constructing concrete lining for the Wilson Irrigation Company canal. The lining in this canal was installed in 10-ft panels with farm labor • *(Center)* A test section of the same canal with various types of "shotcrete" and concrete linings • *(Right)* Placing of concrete lining with slip form on the Columbia Basin project

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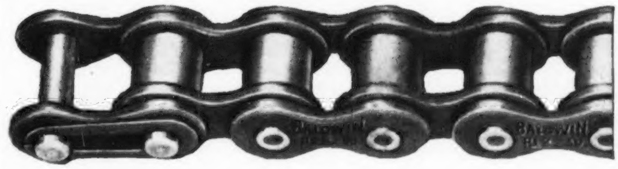

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Lining Irrigation Canals

(Continued from page 408)

Again costs vary widely from job to job. The Bureau of Reclamation estimates the average cost of this lining to range between 75c and $1.00 per sq yd. In some cases the cost may be even greater than the cost of concrete. An example of this is the installation made on the Yellowstone Feeder Canal in 1952, where buried asphaltic membrane of the sprayed type cost $13.63. The prefabricated liner cost $11.70 and the concrete $9.07 per linear foot of canal. The cost of the prefabricated lining will generally be somewhat higher due to the greater amount of hand labor involved.

It is believed that, where well constructed, the prefabricated liner will provide a better seal than the sprayed type, since it is almost impossible to apply the spray without considerable variation in thickness and minor imperfections. Another advantage of the prefabricated liners is the fact that they can be installed without special equipment or experienced labor. The sprayed type in particular may be constructed in cold weather even in the presence of some snow without impairing the job. This makes possible the lining of old canals in nonirrigation season and solves one of the biggest problems presented when the lining of operating canals is considered.

SUMMARY

Linings of major importance in the United States only have been considered. There are other types used to a limited extent and better adapted to special conditions, but their consideration would require more time than justified. Cost is an important factor and must always be considered. It is annual cost, including maintenance, which determines the relative economy of linings. When comparing the cost of linings the comparison must be made in terms of equivalent units, since the lined surface of a canal will vary with the surface characteristics of the lining and the thickness of the lining, including the cover, and therefore differs for different types of linings.

It is of greatest importance to use only those types of lining which are adapted to site conditions or so to modify site conditions that the minimum requirements for the lining will be met. It would be folly to use concrete where the elevation of the ground water in winter would closely approach that of the lining. Likewise, the use of membrane linings on porous subgrades is hazardous. Pipe lines should be considered as a substitute for lined canals where there is a possibility they may be cheaper because of heavy grades along the course where water is to be conveyed or where the use of pipe lines would shorten the conveyance distance. There appears to be a real opportunity for the use of flexible pipe in the place of head ditches and farm laterals. The future of the flexible pipe likely depends on the development of a better product and easier methods of moving and coupling fabric pipes.

There are areas where none of the linings discussed are adapted because of the high cost of materials, neither gravel nor good earth lining materials being available locally. In areas such as these soil cement may be the answer. Standard soil cement has been demonstrated to be more durable than plastic soil cement, but has not been used to any extent for lining canals because equipment suitable for compacting soil cement on the side slopes is not available. Consideration should be given to the development of suitable compacting equipment and construction of these linings with a wide base and low sidewalls constructed by building them up in lifts, compacting each layer as it is laid down with a roller. Canals of this shape will not be as efficient hydraulically as those of conventional cross section, but they may be the most efficient section obtainable, considering the restriction on sources of lining materials and absence of equipment for obtaining a satisfactory job using the conventional section.

While much progress has been made in canal lining, there is little doubt that there is still room for improvement. Considering the large expenditures which are likely to be involved in the lining programs of the future, research directed toward the development of new materials, and improved construction practice seems fully justified. Much could be accomplished by a better evaluation of the effectiveness and maintenance requirements of existing linings, and more by incorporating a testing program with normal construction projects. Considerable work has been done along this line, but it is believed the opportunity this affords has not been fully explored.

Irrigation and Food Production

(Continued from page 406)

the speciality foods that contribute to the high standard and variety of our present-day diet. Our supply of fruits, nuts, and fresh vegetables is produced largely on irrigated land.

Expansion of the irrigated area throughout the world will play a vital part in supplying the necessary foods for future populations, although this expansion will probably come more slowly, and at a greater cost than in the past.

REFERENCES

1 Israelsen, O. W., The Historical Background of Reclamation. AGRICULTURAL ENGINEERING, 32 : 321-324, June, 1951.

2 Thorne, D. W. and H. P. Peterson, Irrigated Soils, Their Fertility and Management. 288 pp. illus. The Blakeston Co., Philadelphia, 1949.

3 Malhotra, S. L. and P. R. Ahaja, Review of Irrigation Development and Practice in India. International Commission on Irrigation and Canals, First Congress, New Delhi, 1951.

4 Diffie, Bailey W., Latin American Civilization. Slackpole Sons, Harrisburg, Pa., 182 p. 1945.

5 Helseth, Old S., Fifteen Hundred Years of Irrigation History. *Reclamation Era*, 1947.

6 Clyde, G. D., History of Irrigation in the United States. (In press).

7 U. S. Census, Preliminary Reports on Irrigation and Agriculture, 1952.

8 McArthur, W. C., Economic Aspects of Irrigation Farming on the High Plain. Third Annual Irrigation Conference, Lubbock, Texas, July, 1952. Mimeo.

9 Anonymous, The Reclamation Program. 1948-54 USBR, 1948.

10 Anonymous, Endless Frontier. *Time* 58 (5) 48-51, July 30, 1951.

11 Boyd-Orr, Lord John, The Food Problem. *Scientific American*, 183 (2) 11-15, August, 1950.

12 Richter, I. H., Aspects of the World Food Situation. *Foreign Agriculture*, 15 (10) 210-213. October, 1951.

13 Nelson, Wesley R., Water and Our Future. U.S. Bureau of Reclamation 36 p. 1951.

14 Statistical Yearbook, 1951, 616 p., United Nations, New York, 1951.

15 Shaw, Byron T., Our Job is to Fill the Fifth Plate, *Reclamation News*, 16 (5) 1-7 June, 1952.

16 Jones, Lewis A., Effects of Drainage on Agricultural Production. AGRICULTURAL ENGINEERING, 33 (7) 415-416. July, 1952.

17 Sixteenth Census of U.S., Agriculture, Vol. III, 1940.

18 Rosin, Jacob, Road to Abundance, *Readers Digest*, 11-14, September, 1952.

19 U.S. Bureau of Agricultural Economics, Agricultural Statistics, 1951: USDA, Washington D.C., 1951.

20 U.S. Bureau of the Census, Statistical Abstract of the United States: 1952. (Seventy-third edition) Washington, D.C., 1952.

INSTRUMENT NEWS

KARL NORRIS, Editor

Sponsored by the ASAE Committee on Instrumentation and Controls. Contributions on agricultural applications of instruments and controls and related problems are invited, and should be submitted direct to K. H. Norris, Agricultural Research Center, Beltsville, Md.

A Kymograph

W. H. M. Morris
ASSOC. MEMBER ASAE

FOR the current study of dairying in the agricultural engineering department at Cornell University, a simple and accurate method of recording time-and-motion studies was needed. Following were the requirements:

1 A single observer should be able to record accurately the actions of one or two operators.

2 The cycle of operations would not always be regular and might not previously be known to the observer; the instrument must be flexible in use.

3 Recording should occupy as little of the observer's time and attention as possible.

4 Observation and recording should be achieved with a minimum of fatigue.

5 Tabulation of the record should be simple and rapid.

A kymograph* has been constructed moving a 2¼-in wide tape past a writing window at 10 in per min. Observations are recorded on the tape in the form of an operator activity record or a machine chart. The record is tabulated by measuring the distances between marks on the tape. A clipboard holds paper for making a layout sketch of the work area and any necessary notes, and a stop watch is provided as a check.

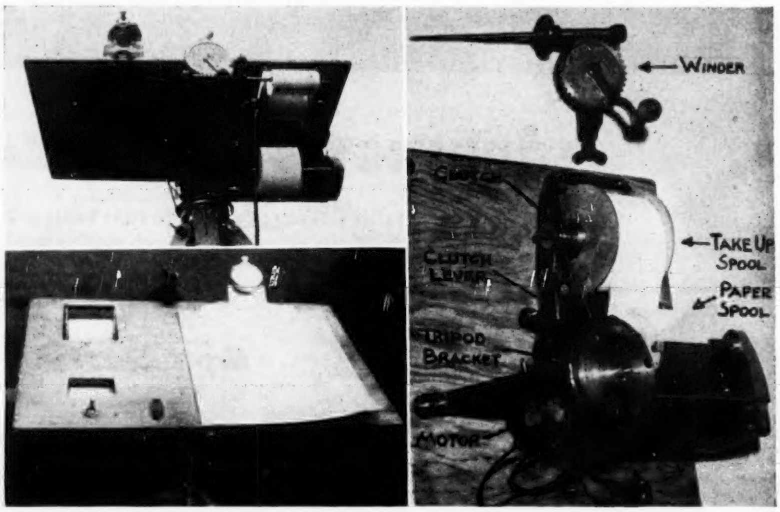
An adding-machine carriage forms the basis of the unit; it has been modified to release the paper from the left side instead of from the right. A synchronous motor drives the paper roller through a reduction gear, giving a peripheral speed of the roller of 10 in per min. The motor also drives the take-up spool by a spring-belt drive through a dog clutch. The clutch is disengaged to rewind the paper off the take-up spool. Most clock motors do not have adequate torque to drive both the paper roller and the take-up spool. The paper is wound off by a simple but strong winder with a worm-and-wheel reduction; these winders are sold to wind bobbins for hand weavers.

A 50-ft reel of electric cable is used to bring power to the instrument and no difficulty has been experienced in the field in finding an outlet within this range.

*An apparatus for recording, in this case of time studies.

The author—W. H. M. MORRIS—is a member of the agricultural engineering faculty at Cornell University.

AUTHOR'S NOTE: The author acknowledges with gratitude the assistance and encouragement he received from C. W. Terry.



Three views of the kymograph developed in the agricultural engineering department at Cornell University for recording time-and-motion studies

Dashes are made on the paper to indicate the beginning and the end of the elements each of which is identified by a symbol letter. A hand guide is provided on the instrument to maintain the location of the hand of the observer so that dashes will be made from the same position in the window each time. Two small pointers are also provided to help in this. When two men are being observed, the actions of each are recorded on different sides of the paper as it passes under the window. Elements of 0.02 min duration can be correctly recorded, but if several come in succession it is hard to record the symbol letters. Elements of 0.01 min duration can easily be recorded without the symbol letters.

The data are quickly tabulated after measuring the distance between the marks on the tape with a ruler divided into tenths of an inch (equivalent to 0.01 min.) The instrument has been calibrated with a stop watch and checked by timing the same operation on cine film taken at 1,000 frames per minute.

It is believed that this instrument is an original development, but the author would be interested to hear of any other similar devices.

Proposed Manpower Legislation

ON MARCH 11, 1953, Representative Leroy Johnson of California introduced in Congress a bill, H.R. 3893, to amend the Armed Forces Reserve Act of 1952 to provide for the orderly and selective recall to active duty in the military services of members of the military reserves so as to afford the most effective utilization of manpower resources. Senator Ralph E. Flanders of Vermont has introduced corresponding Senate Bill S. 1551.

In general, these bills provide for the establishment of a National Manpower Board, which would be composed of both military and civilian persons and would allocate reserve specialized manpower as needed in time of emergency. It would establish criteria governing the call to active duty of the growing reserve forces to insure that both military and productive needs of the country would receive judicious consideration in the resolution of specialized manpower problems.—*From Engineers' Joint Council Engineering Manpower Newsletter No. 37, May 15, 1953.*

NEWS SECTION

Ferguson New Chairman of Mid-Central Section

JOHN M. FERGUSON, extension agricultural engineer, Kansas State College, was elected the new chairman of the Mid-Central Section of the American Society of Agricultural Engineers at the Section's yearly meeting held this year at Saint Joseph, Mo., on March 27 and 28. He succeeds Chauncey W. Smith, University of Nebraska.

The three new vice-chairmen elected at the meeting include J. G. Andros, research and product development engineer, Butler Mfg. Co.; D. A. Kitchen, assistant extension engineer, University of Nebraska, and J. W. Funk, assistant professor of agricultural engineering, Kansas State College.

The new secretary of the Section is F. D. Yung, research engineer in rural electrification, University of Nebraska.

Luebcke New Chairman Ohio Section

HENRY N. LUEBCKE, one of the engineers of the Soil Conservation Service, USDA, stationed at Wapakoneta, Ohio, was elected chairman of the Ohio Section of the American Society of Agricultural Engineers at the Section meeting held in conjunction with a meeting of the Michigan Section at Toledo, Ohio, on May 9. He succeeds T. P. Christen, Jr.

The new vice-chairman of the Section is Paul G. Strom, supervisor of agricultural extension in the market development division of the American Steel and Wire Division, United States Steel Corp.

The new secretary of the Section is William H. Johnson, assistant agricultural engineer, Ohio Agricultural Experiment Station.

Walker Named Chairman of Minnesota Section

AN ENTHUSIASTIC group of approximately 40 agricultural engineers attended the spring meeting of the Minnesota Section of the American Society of Agricultural Engineers held in St. Paul on May 8. Following registration at the agricultural engineering building on the University Farm campus of the University of Minnesota at St. Paul, an inspection trip was made to the plant of the Anderson Corporation at Bayport. This company manufacturers wooden residential window units in several styles and is favorably known, not only for a high-quality product, but also for excellent labor-management relations extending over several decades. At the conclusion of the tour, lunch was served in the Anderson cafeteria.

The afternoon was devoted to three technical discussions with Section Vice-Chairman Darrell W. Walker presiding. Glenn F. Rowell, engineer, Fire Underwriters Inspection Bureau, discussed problems involved in farm wiring and demonstrated several new and superior products for use in this field. F. W. Duffee, agricultural engineering department, University of Wisconsin, speaking on "Harvesting Green Gold" predicted that silage would ultimately surpass hay in importance as a dairy feed in Wisconsin and Minnesota. Philip W. Manson, agricultural engineering department, University of Minnesota, was the final speaker of the afternoon. He told of his recent experiences in helping establish an agricultural engineering department in Israel and described the conditions of particular interest to agricultural engineers in that new state.

High lights of the annual dinner, in addition to good food and fellowship, were the election of officers for the coming year and an address by ASAE President Ivan D. Wood. Section members unanimously approved the recommendations of the Section nominating committee and the following officers were named: Chairman, Darrell W. Walker, parts and service merchandise manager, Northwest Tractor and Equipment Co.; vice-chairman, B. G. Van Zee, chief engineer, automotive div., Minneapolis-Moline Co.; and John Strait, associate professor, agricultural engineering dept., University of Minnesota, secretary-treasurer.

President Wood stressed the need for vision on the part of agricultural engineers; the ability to see and grasp opportunities for service on new frontiers. Engineers, he stated, should elevate their thinking above the stereotype which in certain instances means above the relatively narrow range of their technical education. Few engineers, he stated, fail because of technical incompetence. In closing he emphasized two points. First, that members of our profession should develop themselves along the line of self-expression, and secondly, that all engineers should gain a working knowledge of the social sciences and place such knowledge to use in the communities in which they live.

Following the dinner, Prof. C. K. Otis, general chairman of the Local Arrangements Committee for the 1954 annual meeting, which will be held on the University Campus in St. Paul, called an informal group meeting to discuss and develop preliminary plans for this event. Facilities which will be available to the Society at the time of the meeting seem very adequate. The reasonable cost of food and lodging on the University Campus is likely to be a major factor in promoting a large attendance at the 1954 annual meeting.

ASAE Meetings Calendar

June 15 to 17—46TH ANNUAL MEETING, Hotel William Penn., Pittsburgh, Pa.

August 31 to September 2—NORTH ATLANTIC SECTION, Long Island Agricultural and Technical Institute, Farmingdale, L. I., N. Y.

December 7-9—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

Buchinger Heads Michigan Section

WILLIAM G. BUCHINGER, farm service engineer, Detroit Edison Co., was elected the new chairman of the Michigan Section of the American Society of Agricultural Engineers at a meeting of the Section held in conjunction with the Ohio Section at Toledo, Ohio, on May 9. He succeeds J. R. Schram.

Three new vice-chairmen were elected by the Section membership: T. J. Brevik, assistant professor of agricultural engineering, Michigan State College; W. M. Carleton, also of the MSC agricultural engineering staff, and C. B. Richey, harvesting engineer, research engineering department, Dearborn Motors Corp.

The new secretary of the Section is E. H. Kidder of the MSC agricultural engineering staff.

The new nominating committee of the Section includes H. F. McColly, Michigan State College; D. B. Poor, Great Lakes Steel Corp., and H. C. Wolsey, The Oliver Corp.

Earp Heads Virginia Section

U. F. EARP, associate professor of agricultural engineering, Virginia Polytechnic Institute, Blacksburg, was elected chairman of the Virginia Section of the American Society of Agricultural Engineers at its meeting held at Natural Bridge, Va., May 1 and 2. He succeeds J. L. Calhoun of the Virginia Agricultural Extension Service.

Three vice-chairmen were elected for the coming year, including K. R. Cline, agricultural engineer, Southern States Co-operative; Roy B. Davis, Jr., agricultural engineer turned farmer, Paces, Va., and P. B. Potter, agricultural engineer, Virginia Agricultural Experiment Station.

McNeil Marshall, associate agricultural engineer, Virginia Polytechnic Institute, was re-elected secretary of the Section.

The new nominating committee of the Section for the coming

(News continued on page 416)

J. L. Calhoun (right), retiring chairman, Virginia Section, ASAE, transfers the duties of his office to the new chairman, U. F. Earp (center) while Section Secretary McNeil Marshall looks on

NEWS SECTION (Continued from page 414)

year consists of S. H. Byrne, J. W. Sjogren, and J. H. Lillard, all of Virginia Polytechnic Institute.

More than 70 persons — members and friends of ASAE and members of the Virginia Student Branch of the Society — attended the meeting which is reported to be a most successful event.

Schudt New Chairman of Alabama Section

HAROLD M. SCHUDT, general manager, Gadsden, Ala., Works, Allis-Chalmers Mfg. Co., was elected the new chairman of the Alabama Section of the American Society of Agricultural Engineers at the Section meeting held on the campus of Alabama Polytechnic Institute at Auburn, May 1 and 2. He succeeds C. A. Rollo, manager of the Grimes Tractor and Implement Co. of Montgomery, Ala. The new vice-chairman of the Section elected at this meeting is A. W. Cooper, agricultural engineer (BPISAE), U.S. Department of Agriculture, stationed at Auburn.

J. L. Butt, associate agricultural engineer, Alabama Agricultural Experiment Station, Auburn, was re-elected secretary-treasurer, and Hurst Mauldin, senior agricultural engineer, Alabama Power Co., Birmingham, was elected reporter of the Section.

About 75 ASAE members and guests attended the meeting. The program consisted of a tour of the API agricultural engineering farm, a presentation by representatives of the Alabama Student Branch of ASAE, a barbecue, and five talks. In addition, members tried their hand at fishing in one of the college ponds and some stayed over for the Auburn-Georgia Tech track meet on the afternoon of May 2.

The Student Branch representatives discussed what they considered to be "needs" of the employment aspects of agricultural engineering. They pointed out that many company representatives seeking personnel through the college placement service do not know what agricultural engineers are. An example was quoted of the representative of a St. Louis firm who was not even aware of agricultural engineering and who, upon being informed of the curriculum, hired two graduates. The need for educating the general public to agricultural engineering was also effectively presented with impressive supporting data. In a discussion that followed, the Alabama Section voted to improve its public relations work and the office of reporter was added to the other section officers.

Speaking after the barbecue, Admiral A. T. Sprague, Jr., USN (retired), gave an interesting and humorous account of navy notables, both real and legendary. D. F. King of the API poultry department told how to make "dollars from poultry" using a flannelboard speaking aid most effectively. Clarence Wilson of the API soil testing laboratory outlined the sampling and testing procedures for soil analyses. R. G. Bledsoe, farm machinery loan specialist of the First National Bank of Montgomery, described the intricacies of equipment loans and presented an optimistic outlook for the future. Carl Rehling, state toxicologist, often called the South's greatest detective, concluded the program with an illustrated discussion of the place of science in solving crimes. He showed examples of scientific evidence that had reversed the findings of more casual examinations in the interest of justice.

NEWS OF ASAE MEMBERS

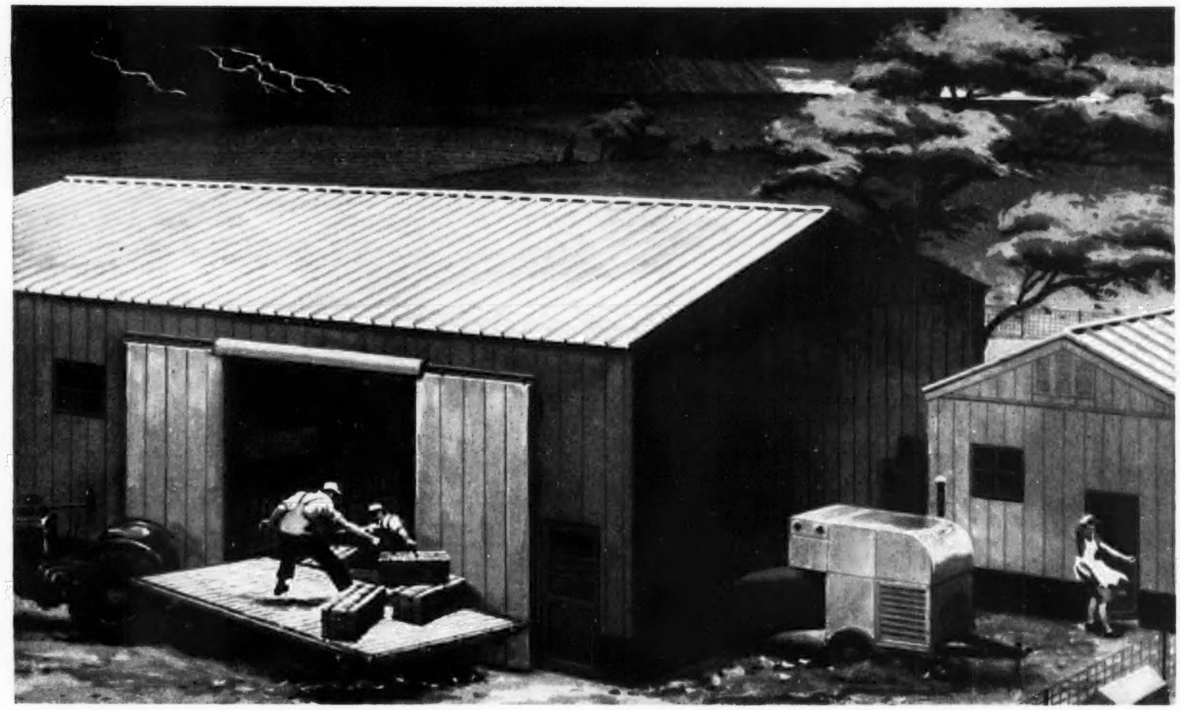
K. R. CHARIA, industrial advisor and engineer, Madras, India, has recently been appointed expert member on a new committee on tractor service of the Ministry of Agriculture and Food of India. The committee is to study questions relating to the import of tractors and spare parts, and the resources of importers of these items. It is to outline policy on standards to be maintained in importing tractors, parts, and equipment for use in the agriculture of India.

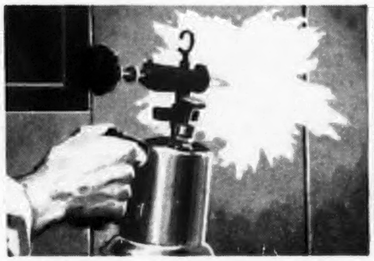
HERMAN J. FINKEL, an early graduate of the professional curriculum in agricultural engineering at the University of Illinois, has been named head of a newly organized department of agricultural engineering at the Hebrew Institute of Technology, Haifa, Israel. Assisting Mr. Finkel in the organizational stages has been P. W. Manson on leave from the University of Minnesota. The curriculum has been developed in collaboration with the Agricultural College, Hebrew University of Jerusalem, at Rehovot near Haifa. The freshman and sophomore years are devoted to general engineering subjects at the Institute. Agricultural subjects are taken at Rehovot during the junior year. Students return to the Institute for the fourth year and may elect one of two options, soil, water and farm buildings or farm power, machinery and rural electrification. By means of transfer students from the civil and mechanical engineering departments, the agricultural engineering curriculum will get under way immediately with students enrolled in the freshman, sophomore, and junior years.

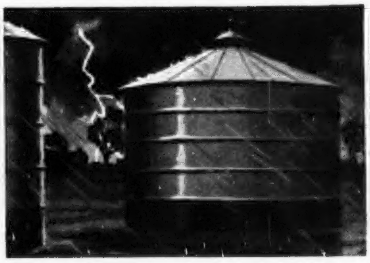
HOWARD M. RAILSBACK, sometimes called the dean of farm implement advertising directors, is retiring June 6 after being a member of Deere and Company's advertising department since 1911 and its director since 1917. Mr. Railsback graduated from the University of Illinois in business administration in 1911 and immediately joined the Deere advertising staff as a copy writer, being promoted to copy chief in 1915 and director of advertising in 1917. In addition to his accomplishments in the field of advertising, Mr. Railsback is author of a book of verse, "Songs of the Soil," and one of his poems, "Defenders of the Second Line," was reprinted and given wide circulation by the Secretaries of War and Agriculture during World War I to stimulate agricultural production. In addition to his membership in ASAE, Mr. Railback is a member of the National Industrial Advertisers Association and the Association of National Advertisers, and in 1944 he was awarded an honorary American Farmer degree by the National Future Farmers' Association.

ROY T. TRIBBLE, who was on duty with the U.S. Navy for some time, and more recently returned to his former position of agricultural engineer at the Hawaii Agricultural Experiment Station, has resigned to accept a position as sales engineer with the Oldfield Equipment Co., 430 W. 71st St., Cincinnati, Ohio.

This is Pittsburgh where the ASAE 46th Annual Meeting will be held June 14 to 17, 1953. The Allegheny River from the upper left joints the Monongahela River from the right to form the Ohio. In this setting is the "Golden Triangle" of Pittsburgh. Headquarters for the ASAE meeting will be in the Hotel William Penn, which is located in the shadow of the square-topped United States Steel Corporation building. The highway in the right foreground is routes US 22 and US 30 from the west. The meeting program will include an opportunity to see the industries of the Pittsburgh area.







Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

BARRIER, DONALD A. — Sales engineer, Woodin & Little, San Francisco, Calif. (Mail) 1579 Revere Ave.

BLACK, GEORGE L., JR. — Sales engineer, Southwest Equipment Co. (Mail) Box 175, Trinidad, Tex.

BLAIR, WILLIAM S., JR.—Student, Agricultural & Mechanical College of Texas. (Mail) Box 5976, College Station, Tex.

BROWN, JOHN T.—Executive vice-president, J. I. Case Co., 700 State St., Racine, Wis.

CHURCH, WARREN R.—Special graduate research assistant, Michigan State College, East Lansing, Mich. (Mail) 207 Agricultural Engineering Bldg.

DENARO, LOUIS F. III—Territorial manager, John Deere Plow Co. (Mail) Box 73, West Columbia, S. C.

DUNNAM, BLANTON E. — Student, University of California, Davis, Calif. (Mail) Apt. L-8 Aggie Villa

FORTNER, J. LEROY—Pasture specialist, Superior Fertilizer Co. (Mail) 2820 Oak St., Sarasota, Fla.

GREENBERG, M. — Engineering assistant, USDA, 240 23rd St. E., Saskatoon, Sask.

HARRELL, WILLIAM J.—Work unit conservationist, (SCS), USDA. (Mail) PO Box 367, Punta Gorda, Fla.

HEDDEN, SCOTT L.—Student, University of Nebraska. (Mail) 4332 Overland Pkwy., Toledo 12, Ohio

HEMSTEGER, JOHN D.—Student, Michigan State College. (Mail) 2205 Yankee St., Niles, Mich.

IMIG, ROY M. — Project engineer, Portable Elevator Mfg. Co. (Mail) Minier, Ill.

KING, VERL G.—Trainee, Cessna Aircraft Co., Wichita, Kan.

KONDAL, RALPH W. — Student, Michigan State College. (Mail) 1004 McKinley Ave., Bay City, Mich.

KRUSE, RICHARD W.—Chief engineer, Valley Mfg. Co., Valley, Neb.

LOVELACE, DELBERT J.—Construction electrician, U.S. Navy. (Mail) Box 472, Stratford, Okla.

LUECHT, SYLVAN F.—Sales engineer, Food Machinery & Chemical Corp., Lakeland, Fla. (Mail) 554 Pablo St.

MCFARLIN, JOHN F.—Area engineer (SCS), USDA, Ocala, Fla. (Mail) 220 N. Tuscawilla St.

MILLER, FOREST L.—Agricultural engineer (SCS), USDA, Baker, Ore. (Mail) 2450 Baker St.

MORGAN, ROBERT G.—District manager, Industrial Div., Timken Roller Bearing Co., 1518 Fifth Ave., Moline, Ill.

NIENHUYS, HENDRIK C.—Manager, Connecticut Shade Tobacco Growing Div., H. Duys & Co., Inc. (Mail) 238 Longmeadow St., Longmeadow, Mass.

NUZMAN, CARL E.—Junior engineer, David Bradley Mfg. Works. (Mail) 1210 Plass, Topeka, Kans.

PEPE, CHARLES R. — Catalog technician, Minneapolis-Moline Co., Louisville, Ky. (Mail) 503 Central Ave.

(Continued on page 420)

"In use 5 days after I ordered it" SAYS WISCONSIN FARMER

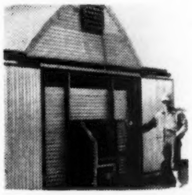
This Dubl-Wall that protects your grain is an exclusive Quonset feature

The Quonset 16 can be equipped with a complete "fan and tunnel" package which conditions your grain, lets you hold it for a favorable market.

QUONSET® 16

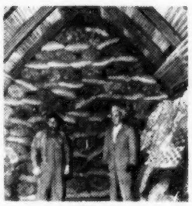
CROP DRIER AND ALL-PURPOSE STORAGE BUILDING

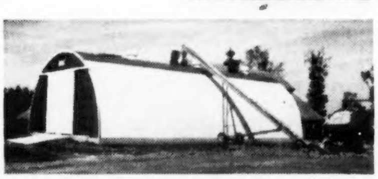
MIDWESTERN FARMERS ENDORSE QUONSETS



"In use in 5 days," says Cecil J. Rhodes, of Whitewater, Wisconsin, of his Quonset 16, equipped with fan and tunnel, for drying and storing ear corn. "I have 2200 bushels in this building now," says Mr. Rhodes.

"A wonderful building because it's so versatile." So Dean M. Hewitt, David City, Nebraska (right), described the Quonset 16. He has 12 of these buildings on his property.





W. R. Mitchell, Grundy Center, Iowa, dried 5500 bu. of ear corn in this Quonset 32 last fall—first crop harvested in his county.

Here's the new building you'll want for your farm. It's the Quonset 16—just right for crop storage . . . and for dozens of other uses.

It's available in a size to fit your needs . . . priced to meet your budget . . . and engineered to handle grain direct from modern harvesting equipment. All-steel quality construction, careful Quonset engineering, and qualified erection crews, assure a long-lasting, good looking building.

Easily expanded, the Quonset 16 meets CCC storage requirements. See your authorized Quonset dealer today or send in the coupon for complete information.

QUONSET PURCHASE PLAN

Your Quonset dealer can arrange convenient terms on the Quonset Purchase Plan. You'll find there's little or no down payment necessary.

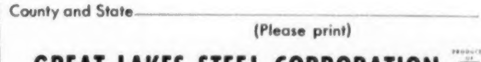
FOR ALL THESE USES . . . THE MOST PRACTICAL BUILDING YOU CAN FIND TODAY

Crop drying and storage
Tool shelter
Feed and seed storage
Farm shop
Garage
Hog house
Poultry house

YOU NAIL TO STRAN STEEL FRAMING

STRAN-STEEL AND QUONSET REG. U.S. PAT. OFF.

The Quonset Line—Engineered for America's Farmsteads



Gentlemen: Please send me your literature on Quonset buildings for farm use.

Name ____________________

Route and P.O. ____________________

County and State ____________________

(Please print)

GREAT LAKES STEEL CORPORATION

Stran-Steel Division   Ecorse, Detroit 29, Mich.

NATIONAL STEEL CORPORATION

36

Applicants for Membership

(Continued from page 418)

PETERS, LEO C. — Student engineer, John Deere Waterloo Tractor Works. (Mail) 515 S. Monroe, Smith Center, Kans.

RATHBUN, HAROLD E.—Trainee, Caterpillar Tractor Co. (Mail) RR 2, Sedan, Kans.

RODEHEAVER, DONALD G.—Instructor, West Virginia University. (Mail) PO Box 15, Deer Park, Md.

ROGERS, CLARENCE J. — Instructor in farm shop courses, Agricultural Engineering Dept., University of Florida. (Mail) Agricultural Engineering Dept., Gainesville, Fla.

ROSE, J. R. — Sales manager, Midwestern Div., Townsend Co., 208 S. LaSalle St., Chicago 4, Ill.

SHAFFER, E. W.—Assistant district manager, International Harvester Co., 931 N. 24th St., Birmingham, Ala.

SHARP, CARL R.—Sales engineer, Hilbe Engineering, Inc., 130 S. Grand Ave., Glendora, Calif.

SMITH, ELMER W.—Work unit engineer, U.S. Indian Service, S.M.C.O., Box 1060, Wewoka, Okla.

VAN DYKE, CARROLL E.—Engineer (SCS), USDA, LaBelle, Fla. (Mail) Box W-100

WILKINS, JAMES D. — Student, Oklahoma A and M College. (Mail) Heber Springs, Ark.

TRANSFER OF MEMBERSHIP GRADE

BYG, D. M.—Instructor, Agricultural Engineering Dept., Ohio State University, Columbus 10, Ohio. (Mail) Ives Hall (Associate Member to Member)

NEW BOOKS

HEATING, VENTILATING AND AIR CONDITIONING GUIDE, 1953 (31st edition). Cloth, xxiv+1560 pages, 6 x 9 inches. Illustrated and indexed. American Society of Heating and Ventilating Engineers (62 Worth St., New York 13, N. Y.) $7.50.

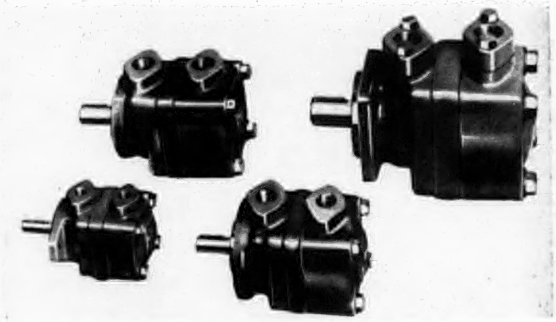
Technical and manufacturers catalog data sections. Subsection and chapter headings and arrangement in the technical data section are substantially the same as for last year's edition. The Technical Data Section has been increased by 32 pages to a total of 1096 pages. The Manufacturers' Catalog Data Section has also been enlarged to 432 pages. Among the new and improved features of this volume are a new section on snow melting, completely rewritten chapters on electric heating and industrial exhaust systems, as well as a new chapter on water vapor and condensation in building construction. New information has also been added on industrial oil and gas burners, short chimneys, industrial degree-days, warm air system design and unit heaters. Simplified cooling load calculations, discussions of radio-active contaminants, a revised friction chart for copper tubing, and an enlarged list of codes and standards pertaining to heating, ventilating and air conditioning, are among improvements found in this edition. The 51 chapters of The Guide are grouped in seven sections and include such topics as: Fundamentals, Human Reactions, Heating and Cooling Loads, Combustion and Consumption of Fuels, Systems and Equipment, Special Systems, and Instruments and Codes. The ASHVE Psychrometric Chart is included separately in larger size, 24 x 32 in and is printed in two colors to facilitate the solution of problems involving air. This chart is based on the most widely accepted data on moist air tabulated in the chapter on Thermodynamics.

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Complete Line of Hydraulic Motors

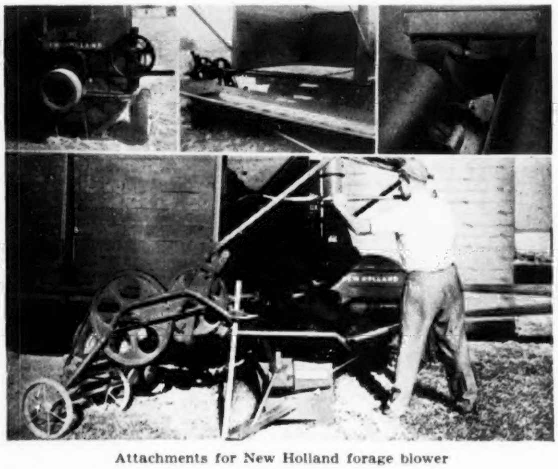
Vickers, Inc., 1516 Oakman Blvd., Detroit 32, Mich., announces production of two new sizes of its vane-type motors, Series M2-300 and M2-400, to supplement the previously released Series M2-200 and M2-500, which completes the range from 5 to 28.5 hp. These motors incorporate Vickers design features of automatic pressure loading, automatic adjustment of both radial and axial clearances, maintenance of a lubricating oil film on both rotor faces and vanes, and rugged but compact and light-weight construction. The best heat-treated alloy steels assure long life and high efficiency with low maintenance requirements. The "rocking beam" construction provides intimate contact between vanes and cam ring without use of conventional spring-type actuators. Rotating parts are in dynamic balance and free from vibration. Mounting adaptability is provided by four combinations of inlet-outlet port position, by a choice of face, flange or foot mounting and of either direct, belt, chain or gear drive. For further information write for Bulletin M-5103.



Vickers complete line of new vane-type hydraulic motors

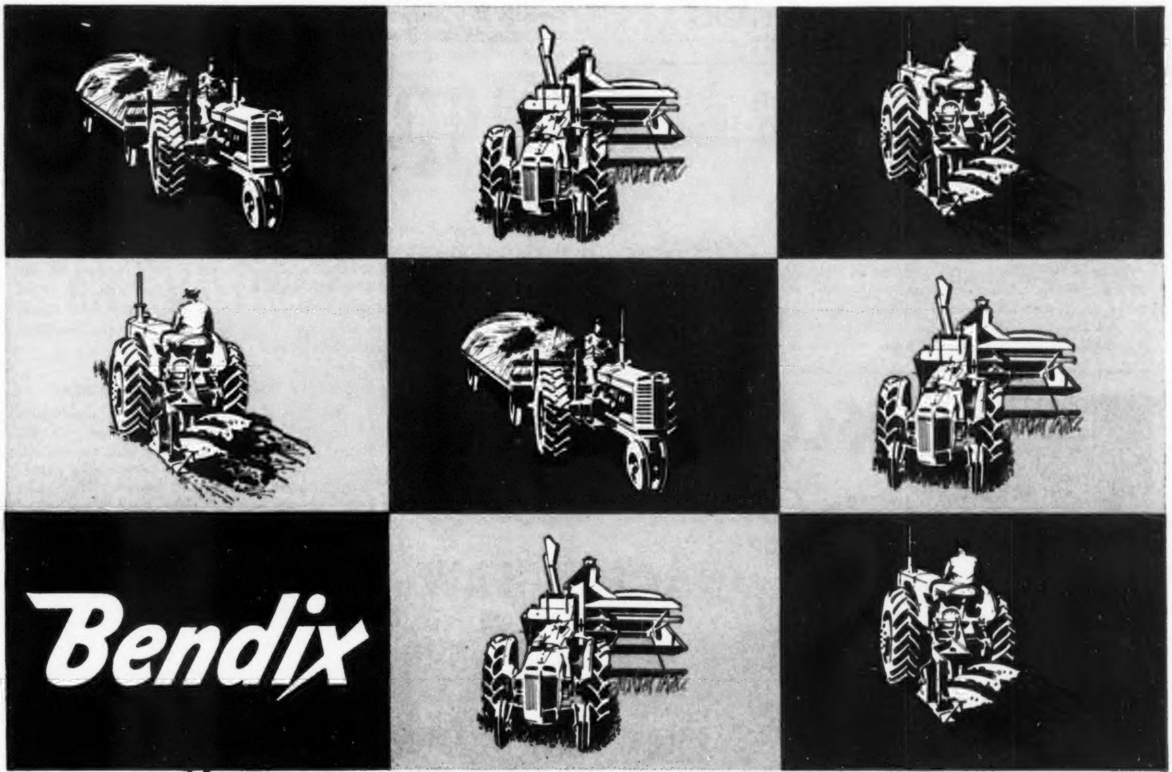
New Attachments for Forage Blower

New Holland Machine Co., New Holland, Pa., announces the new attachments for its forage blower shown in the accompanying illustration. The bottom picture shows the tripod unloader moving chopped grass into the blower. A $\frac{1}{4}$-hp electric motor handles a load weighing $3\frac{1}{2}$ tons. Top left is the mounted unloader powered by the tractor driving blower, which can be set up for either right or left-hand unloading. The extra ratchet wheel shown can be had at additional cost. The center picture shows the false end-gate attachment for use with either tripod or mounted unloader. At the right is shown the new curved blower fan blades to keep chopped material in front of the blades. The hinged extension table shown in the lower and upper middle pictures lengthen the feed table another foot.



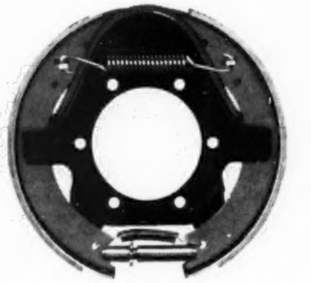
Attachments for New Holland forage blower

(Continued on page 424)



Farm Tractor Brakes...

backed by the greatest name in braking



The Bendix heavy-duty farm tractor brake has powerful and positive holding action in both forward and reverse. Rugged design assures uniform performance day after day, under the most severe field and road work.

For 25 years Bendix has specialized in building brakes for the automotive industry. In that period of time the Bendix Products Division at South Bend has built more than 90 million brakes for passenger cars, trucks and farm tractors.

These are reasons why tractor manufacturers—as well as passenger car and truck manufacturers—look to Bendix as brake headquarters.

Bendix Brakes for farm tractors are specifically designed for the exacting needs of this class of service, combining rugged, dependable and smooth action with low cost. That's why Bendix Brakes are the logical choice for the modern tractor.

Let Bendix farm tractor brake engineers help you solve your brake problems. Write for detailed information.*

*REG. U.S. PAT. OFF.

BENDIX · PRODUCTS DIVISION · SOUTH BEND

Bendix AVIATION CORPORATION

EXPORT SALES:

Bendix International Division, 72 Fifth Ave., New York 11, N. Y. • Canadian Sales: Bendix-Eclipse of Canada, Ltd., Windsor, Ontario, Canada

NEWS FROM ADVERTISERS

(Continued from page 422)

Bearings and Bushings

The Cleveland Graphite Bronze Co., 17000 St. Claire Ave., Cleveland 10, Ohio, will, on request of readers of this publication, send a copy of its catalog which briefly describes its sleeve-type bearings and bushings, including thrust bearings, heavy-wall bearings, main and connecting-rod thin-wall bearings, cam-shaft bearings, etc.

Improved Riveted Roller Chain

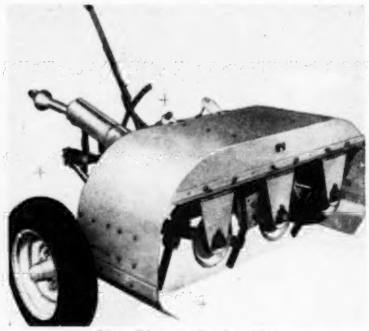
Chain Belt Co. recently introduced the Improved Baldwin Assembly Riveted Roller Chain. It is said to combine the long-wearing characteristics of riveted roller chain with the ease of assembly and disassembly of cottered chain. Supplied in ASA standard and heavy series, 1 through 2½-inch pitch sizes, and multiple widths, the chain is made up and boxed in 10-ft lengths. Baldwin-Rex single-pin couplers are spaced at varying convenient intervals so that any length of chain can be made up without cutting rivets or damaging parts. Further information may be obtained by writing Baldwin-Duckworth Division, Chain Belt Co., Springfield 2, Mass.

Alloy Spring Steels Bulletin

The International Nickel Co., 67 Wall St., New York 5, N. Y., will mail to readers on request a copy of its 18-page bulletin, entitled "Alloy Spring Steels," with charts, tables and photomicrographs. The bulletin compares the mechanical properties of three alloy steels, nickel-chromium-molybdenum (AISI 6150), and silico-manganese (AISI 9262) with plain carbon spring steel (AISI 1095). The conclusion is reached in the bulletin that, for exacting spring service, adequate hardenability, good surface, excellent mechanical properties, light decarburization, and cleanliness, together with reasonable cost, combine to make nickel-chromium-molybdenum alloy steel the one to be employed.

Stalk and Stubble Shredder

New Idea Farm Equipment Co., Coldwater, Ohio, has introduced a new power take-off shredder with advanced safety and mechanical features. It is particularly adapted to shredding tobacco, corn and cotton stalks, also straw, sugar beets, weeds, wild shrubs and sagebrush. It uses three shredding heads with adjustable hammers which achieve 19,225 hits per minute. By using three heads, it cleans two rows and a center at one time, and distributes the pulverized stalks evenly over the soil. There are twenty free swinging hammers—six on each side and eight on the center head. The center hammers are heat treated, with hardened tips, and swing on wax-impregnated rubber bushings for long life and greater efficiency.



New Idea stalk shredder

Outside shafts are spaced approximately 38½ in apart. Anti-wrap shields on both ends of all three hammer shafts cut wrapping to a minimum. The shredder is counterbalanced so that it can be easily lifted and attached by one man. Under normal conditions it is operated in second or third gear.

Roller Chain and Sprocket Bulletin

A new bulletin on Baldwin-Rex roller chains and sprockets has just been published by Baldwin-Duckworth, division of Chain Belt Company. The 54-page book describes inherent advantages of roller chain and illustrates all the popular sizes of Baldwin-Rex roller chains. A section of the bulletin is a treatise on how to select standard roller chain drives, with formulas, tables and examples illustrating procedure, Roller chain dimensions, strengths, weights, and prices are included. A section of the bulletin deals with stock sprockets—their characteristics and prices. Bore, keyway and setscrew information is presented. Proper maintenance of chain drives is reviewed, and important information on chain vises, flexible couplings and coupling covers is provided. The bulletin will be of interest to all who buy, select, and maintain roller chain and allied equipment. Request copies of Bulletin No. 52-1 from Baldwin-Duckworth, division of Chain Belt Co., Dept. P.R., Springfield 2, Mass.

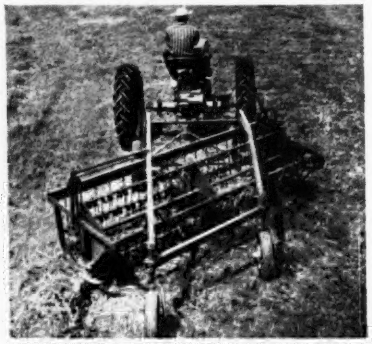
(Continued on page 426)

NEWS FROM ADVERTISERS

(Continued from page 424)

New Side-Delivery Rake

International Harvester Co., Chicago, Illinois, announces the new McCormick No. 5 side-delivery rake. This rake has a heavy, twinbeam frame to permit fast speed without weaving in heavy crops. Twin caster wheels help guide the reel over rough, uneven ground. The ground-driven reel automatically adjusts its speed to the ground speed of the tractor. The reel rakes a full 8-ft swath.



New McCormick No. 5 side-delivery rake

New 1,000-w Electric Plant

Kohler Co., Kohler, Wis., announce a new model (1A21) electric plant which will generate 1000 watts and is especially designed for various portable and semiportable uses. The plant starts automatically when a connected bulb (40 watts or larger), appliance or motor is turned on, and also stops automatically when the load is cut off. It will operate 40 25-watt bulbs at one time, or appliances such as a radio, fan, vacuum cleaner, water system, washing machine, refrigerator and various types of power tools.

The new Kohler model 1A21 electric plant

Oil Hydraulic Equipment Catalogue

Vickers Inc., 1516 Oakman Blvd., Detroit 32, Mich., will send on request a copy of their new catalogue (M-5101) covering their complete line of oil hydraulic equipment. The catalogue provides the latest specification and engineering information on Vickers hydraulic vane-type pumps and motors, valves, power-steering pumps and steering boosters, and other oil hydraulic units specifically designed for equipment in the agricultural equipment and other industries. Requests for the catalogues should be addressed for the attention of M. J. Taup, manager, mobile products sales.

Asbestos Canal Liner

Johns-Manville Corp., 22 East 40th St., New York 16, N. Y., will send on request a copy of its brochure, entitled "Asbestos Pre-Fab Canal Liner," which describes a new J-M product that protects against water seepage from irrigation systems, stock ponds and reservoirs. Developed in cooperation with irrigation engineers, it is made of asbestos and asphalt and will not rot or decay underground.

everyone wants the perfect comfort of

U.S.® Koylon FOAM *Cushioning*

. . . leading designers and manufacturers select U. S. Koylon Foam Cushioning for the ultimate in seating comfort!

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NEW BOOKS

THE FARMER'S TOOLS, 1500-1900, by G. E. Fussell. Cloth, 246 pages, 6 x 9 inches. Illustrated and indexed. Andrew Melrose (Stratford Place, W 1) London. 42 s.

Subtitled "The history of British farm implements, tools and machinery before the tractor came," this work records the antecedents in the line of progress in farm equipment from the beginning of a literate agriculture in 1523 to the beginning of the tractor era. It records that one Fitzherbert authored or published a "Boke of Husbandrye" in that year, the first literature of the country in its field. Reference is made easy by organization of the history into chapters on field drainage, preparing the seedbed, sowing the seed, harvesting the crop, threshing the grain, barn and miscellaneous machinery, and brief retrospect. Supplementary notes, a chronological list of tools, glossary and bibliography add to the reference value.

• • •

RED TRACTOR BOOK (37th annual edition). Buckram, 614 pages, 7 x 10 inches. Illustrated and indexed. Implement and Tractor Publications, Inc. (Kansas City 5, Mo.)

Technical, trade, and service data on principal makes and models of tractors, operated equipment, and components from air cleaners to wagon unloaders. Tractor changes since publication of the preceding edition are listed by make of tractor in a one-page summary.

• • •

CELLULOSE, THE CHEMICAL THAT GROWS, by William Haynes. Cloth, 386 pages, 5½ x 8½ inches. Illustrated and indexed. Doubleday and Co., Inc. (Garden City, New York) $4.00.

Popular treatment of the history of cellulose and of man's progress in utilizing it. One feature, "A Cellulose Chronology," summarizes that progress from the Egyptian development of papyrus before 3500 B. C., to new steps in the chemical and paper industries in 1950. Chapter headings are: oldest material: newest uses, cellulose becomes a chemical, guncotton from war to peace, the cellulose mystery, collodion to film, finer than cobwebs, man-made fibers come to America, new fibers: better fabrics, clean, fresh, and visible, pyroxylin for protection, protection plus decoration, plastics pioneering, materials for modern industries, chemical cotton, wood cellulose, cellulose today and tomorrow.

NEW BULLETINS

Strength of Auto-Nailer Assembled Skids, by E. George Stern. Virginia Polytechnic Institute (Blacksburg) Wood Research Laboratory Bulletin No. 10 (December, 1952). Reports generally favorable results of exploratory tests on the effectiveness of Auto-Nailer assembled lumber units, compared with hand hammer nailing with plain shank nails.

Twenty-Eighth Annual Progress Report of the Washington Farm Electrification Committee, by J. Roberts. Washington Farm Electrification Committee (Pullman, January, 1953). A review of the work done in 1952, including reports on brooding tests; a plywood self-feeding silo; bean drying with forced, heated air; construction of an experimental grain drier; molasses pumps for grass silage; an electric pump for silo wall preservatives; comparison of various methods of brooding, and fair exhibits.

Let's Take Care of our Farm Electrical Equipment, by Wm. H. Knight. Idaho Farm Electrification Committee (Moscow). Leaflet No. 20 (December 1952). Maintenance practice recommendations for safety and economy.

Efficient Milk Can Conveyor Design for Dairy Plants, by Carl W. Hall, Article 35-25, reprint from the Quarterly Bulletin, vol. 35, no. 2 (Nov., 1952), Michigan Agricultural Experiment Station (East Lansing). A chart is presented which can be used for selecting the optimum incoming conveyor length based on the can-dumping rate. A time study analysis showed that most incoming conveyors are too short. Recommendations are given for designing an efficient receiving room conveyor on the basis of time study data.

Loose Housing of Dairy Cattle, by W. Kalbfleisch, V. S. Logan, and J. W. White. Department of Agriculture (Ottawa, Can.) Publication 874 (May, 1952). Information on layout, features, construction, and practices applicable to Canadian conditions.

Home-Grown Timber for Your Farm Buildings, by E. C. Schneider and E. B. Walker, Vermont Agricultural Extension Service (Burlington) Brieflet 886. A 9 x 12-inch double-folded sheet showing species in order of preference for various framing applications; how to pile lumber for rapid and uniform seasoning; and identification of trees.

Heating Rural Homes with Space Heaters, by R. E. Stewart and Ross A. Phillips. Missouri Agricultural Experiment Station (Columbia) Bulletin 586 (August, 1952). Selection, installation, and use recommendations based on experimental work done as a part of North Central Regional Project NC-9. *(Continued on page 432)*

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Josepn. Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — 1953—FEBRUARY—O-907-605, 911-606, 7-501, 6-502, 10-503, 11-504. MARCH—O-50-505, 82-507, 99-509, 102-510. APRIL—O-88-511, 87-512, 90-513, 118-514, 115-515. MAY—O-140-516, 164-517, 182-518, 190-519.

POSITIONS WANTED—1953—JANUARY—W-827-152, 884-154, 896-157. FEBRUARY—W-893-160, 895-161, 915-162, 16-2, 4-3, 21-5, 19-6, 26-7, 27-8. MARCH—W-29-9, 56-10, 67-11, 79-15, 85-16, 68-17. APRIL—W-97-18, 64-19, 80-20, 134-21. MAY—W-112-22, 120-23, 141-24, 109-25, 162-26, 163-27, 151-28, 169-29, 192-30, 193-31, 196-32.

NEW POSITIONS OPEN

REGIONAL FARM REPRESENTATIVE for West Coast with commercial extension organization. Technical promotion and contact work on development of farm uses and market for aluminum, with basic approach including encouragement of research on farm uses and applications. Contact college personnel, agricultural leaders, distributors, etc., and provide technical assistance on development and applications. Native of West Coast area with farm background in that area and BS deg in agricultural engineering, or equivalent from a college on the West Coast. Minimum agricultural engineering or related experience 5 yr. Able to work with people. Extensive travel in West Coast area. Excellent opportunity for well qualified man. Progressive, developing organization. Age 30 or over. Salary open. O-209-523

AGRICULTURAL ENGINEER and assistant or associate (2 positions), one for research in power and machinery field; one in soil and water. Development of equipment and irrigation systems for specialized conditions and production operations in semi-tropical area. Possibly limited teaching. MS deg in agricultural engineering or equivalent in education and experience. Farm background and research or design experience desirable. Usual personal qualifications for college research work; ability to cooperate with other individuals and organizations. Fixed increment pay increases. Both positions open July 1. Salary $4700-7500, depending on qualifications. O-206-521

JUNIOR AGRICULTURAL ENGINEER interested in lifelong work doing research in soil, soil chemistry, design, installation and sales of portable aluminum irrigation systems. Prefer college training in agricultural engineering and/or soils and soil chemistry but not required if practical experience and good judgment are combined with an eager desire to progress and to improve agriculture. Must have pleasant disposition and ability to meet people and have honest straightforward dealings with the trade. Wonderful opportunity to grow with small, very progressive scientific organization that has pioneered revolutionary type engineering and application of portable aluminum irrigation equipment based on sound scientific farming practices. Salary open, advancement, and ultimate compensation depending upon responsibility, accomplishments, and desire to succeed. O-208-522

AGRICULTURAL ENGINEER for extension work in farm structures in a midwestern state. BS and MS deg in agricultural engineering, or equivalent preferred. MS deg necessary for advancement. Favorable opportunity, particularly for single man, to work toward MS deg. Extension, teaching, or commercial experience in farm structures or similar types of construction. Usual personal qualifications for agricultural extension work. Must be open-minded and willing to learn if not already trained in extension procedures. Good opportunity for well qualified man. Age, under 32. Salary open. O-147-524

NEW POSITIONS WANTED

EXTENSION, teaching, research, sales or service in soil and water field with public service, distributor, or farming operation. Any location. Willing to travel. BS deg in agricultural engineering, 1948, North Carolina State College. Agricultural engineer with SCS 4 yr. Sales work 4 yr. Traffic work 3 yr. War enlisted and commissioned service in Coast Artillery Corps, 5 yr. Married. Age 34. No disability. Available on reasonable notice. Salary $4200. W-178-23

DESIGN, development, research or management in power and machinery with manufacturer in West or Midwest. BS deg in mechanical engineering, 1938, Montana State College. Design and development experience 14 yr, including 11 yr in agricultural machinery and 5½ yr as chief engineer with full responsibility for developing a line of equipment for material handling in western agriculture. Currently in consulting practice in farm equipment design and development. Married. Age 37. Available on 30 to 60-day notice. Salary $12,000-15,000 (prefer incentive basis) W-204-34

DESIGN, development, research, extension, or management in soil and water or irrigation field with industry or public service in northern half of USA, western Europe, or South America. BS and MS deg in agricultural engineering, 1950 and 1953, Kansas State College. Experience 15 yr as operator and/or owner of livestock and small grain farm. Assistant extension irrigation engineer 3 mo. Extension engineer in soil and water and power and machinery field one year. ACP supervisor in county one year. Research assistant in sprinkler irrigation while working for MS deg. War enlisted service with Air Corps 2½ yr as aircraft electrical accessory repairman. Married. Age 35. No disability. Available Aug. 1. Salary open. W-205-35

(Continued on page 432)

Personnel Service Bulletin

(Continued from page 430)

DESIGN, development, research or construction, soil and water field, industry, western USA. BS deg in agricultural engineering, 1949, Purdue University. Experience 4 yr in present work, as agricultural engineer in charge of conservation engineering work in area of 6 counties. Surveying, designing, planning, layout, and supervision of construction for agricultural drainage, erosion control, and water impounding structures. Related training and supervision of personnel. War enlisted and cadet service in naval aviation. Commissioned in Naval Reserve. Married. Age 27. No disability. Available on 30-day notice. Salary open. W-200-36

DESIGN, development, extension, or research in power and machinery, farm structures, or soil and water, with industry or public service, in Rocky Mountain region or Canada. Bs deg in engineering (major in civil engineering, minor in agriculture), 1950, University of Wyoming. Farm experience 3 yr. Agricultural engineering research, University of Wyoming 8 mo. Engineering department, Union Pacific RR, 1½ yr. Junior engineer, Washington State department of highways one year. War enlisted service in Army Air Corps, over 2 yr. Married. Age 27. Mild residuals of polio. Available on reasonable notice. Salary open. W-203-37

TEACHING, research, or extension in agricultural engineering. Any location. Ph.D deg in agricultural engineering from Cornell University. Extension engineer in New York 5 yr. Teaching agricultural engineering at Cornell, 2 yr. Extension engineer in Arkansas, 4 yr. Government service (primarily rural electrification) 12 yr. Age 46. Married. Registered engineer in D.C. Available July 1, 1953, as result of Government reduction-in-force. Salary open. W-210-38

RESEARCH, development, design, or management in rural electrification, farm structures, power and machinery or product processing, with industry or public service, preferably in Midwest. BS deg in agricultural engineering, Kansas State College. Farm background. Commissioned service in Cavalry-Infantry, August, 1951, to expected relief from active duty Aug. 3, 1953. Married. Age 27. No disability. Available Aug. 3. Salary open. W-215-39

DEVELOPMENT, research, or management in soil and water field with experiment station or farming operation. Any location. Agricultural engineering graduate, 1930, Hungarian Agricultural University. Manager of soils and fertilizers research farm for Hungarian Chemical Institute and the Hungarian Agricultural University, 16 yr. Divorced. Age 44. No disability. Available now. Salary open. W-220-40

NEW BULLETINS

(Continued from page 428)

Selection and Use of Engine Antifreezes. American Society for Testing Materials (1916 Race St., Philadelphia 3, Pa. Aug., 1952). Concise information on types, classification by boiling point, installation and servicing, testing, mixing types and brands, re-use, use of stop-leak products with antifreeze, cooling system cleaning, and corrosion inhibitors for summer use, prepared by ASTM Committee D-15 on engine antifreezes. Available at 40 cents per copy, with lower prices on quantity orders.

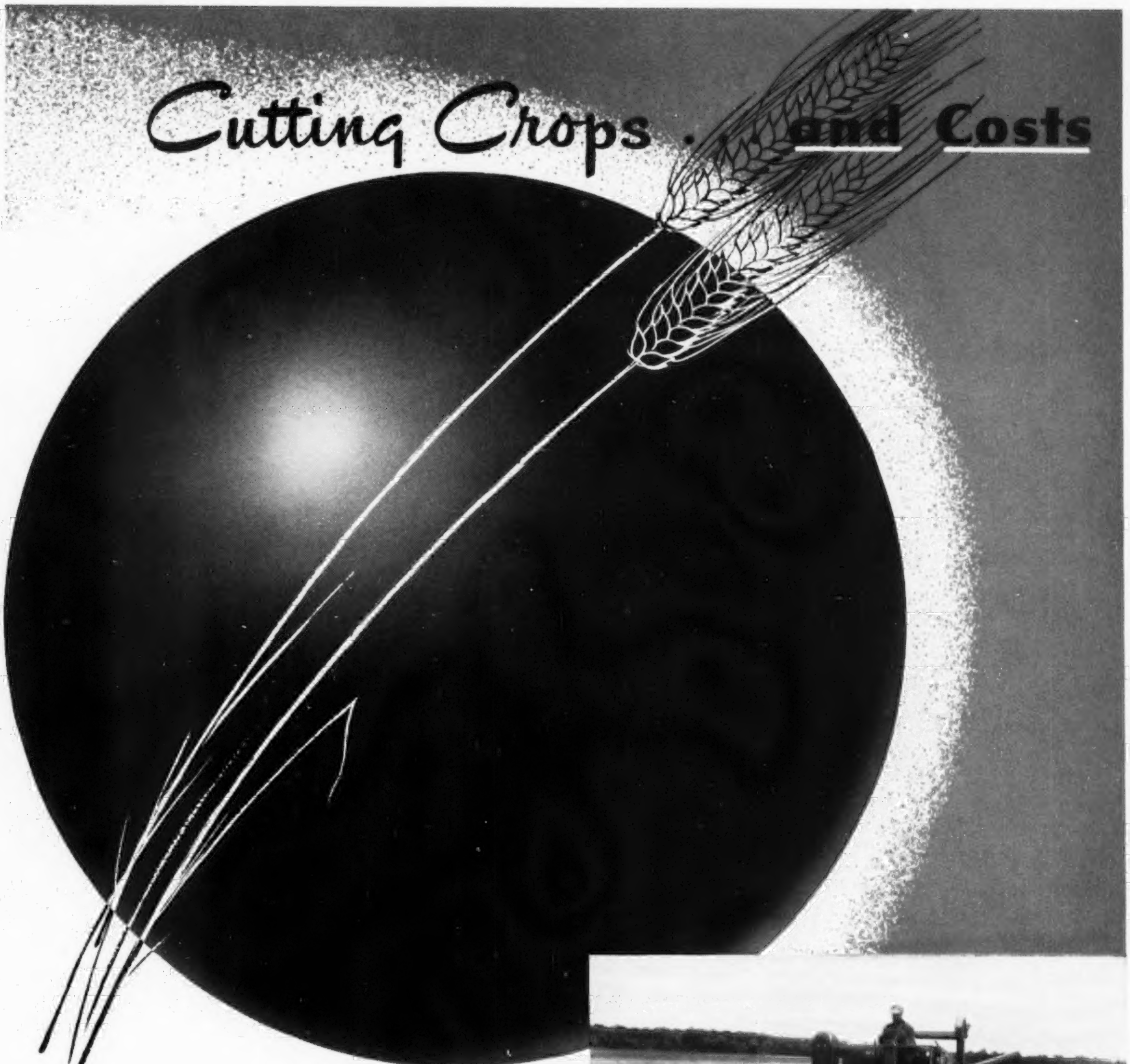
Infrared Lamps—Some Characteristics and Applications, by C. K. Kline and I. P. Blauser. F. E. Circular 1, Ohio Farm Electrification Council and Agricultural Extension Service (Columbus, Jan. 1952). Mimeographed material for leadership training. To be revised and made more widely available in multilith form in 1953.

Brooding Chicks with Infrared Lamps. F. E. Circular 3, Ohio Farm Electrification Council and Agricultural Extension Service (Columbus, Nov. 1952). Multilith recommendations based on research results and reports of successful farm practice.

PROFESSIONAL DIRECTORY

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to ASAE members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Cutting Crops . . . and Costs



In farm implement applications, you can't beat New Departure ball bearings for long life and minimum maintenance. Designed and engineered for a specific job, they stand-up and stand-out in performance and economy.

That's why so many farm equipment manufacturers specify New Departures. This Massey-Harris Clipper "50" combine, for example, employs eight New Departures at such vital points as the lower Pitman, main gear box, cylinder shaft, and power take-off.

Implement dealers, too, prefer New Departure ball bearings because their dependability keeps customers satisfied. Remember, wherever ball bearings are best for the job, the best ball bearings are New Departures!

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE

BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Also Makers of the Famous New Departure Coaster Brake

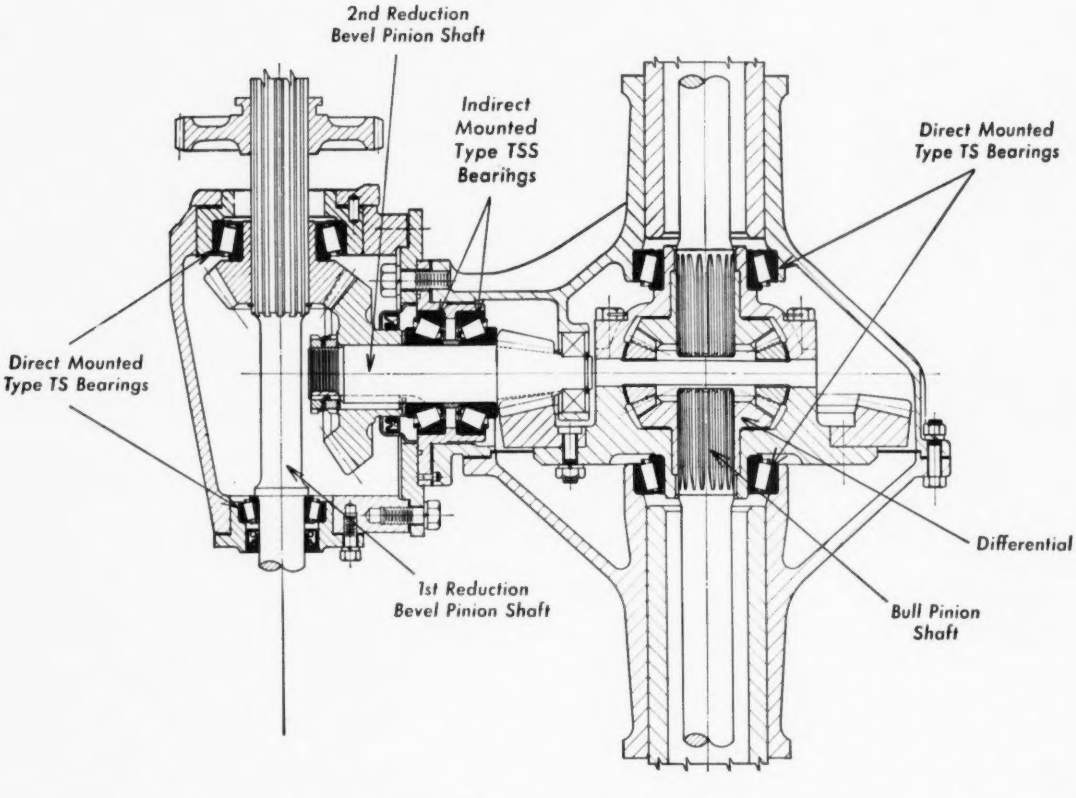
In addition to the Clipper "50" combine shown above, New Departure ball bearing applications are found in the Massey-Harris tractor line, including the Colt, Mustang, and Models "33" and "44."

EVERY MAKE OF FARM TRACTOR HAS TIMKEN BEARINGS; MORE AND MORE IMPLEMENTS ARE USING THEM, TOO!

How John Deere Gears Down a Combine

For 1 m.p.h. Rice Field Work

...with help of TIMKEN® bearings



TO enable the John Deere No. 55 Self-Propelled Combine to travel at the low speeds required for rice harvesting, John Deere engineers decided on a double reduction axle, with all shafts mounted on Timken® bearings.

This solves a rather complicated problem of taking the combined thrust and radial loads on these shafts. Because their rollers and races are tapered, Timken bearings carry both kinds of loads in any combination and still turn freely.

Another reason for using Timken bearings here: they stand up when rough terrain sends sudden shocks back along the shafts. Rollers and races are case hardened with a hard surface to resist wear and a tough core to absorb shocks.

The muddy condition of the rice fields makes a good bearing seal vital at the wheel ends of the axles. Here precision makes Timken bearings shine. Housing and shaft are held concentric, preventing the shaft wobble that can loosen seals and let in mud and water.

For a review of successful bearing applications used by more than 2 dozen farm equipment manufacturers, write for your free copy of "Tapered Roller Bearing Practice on Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION